SBIR 87-1

OMB Approval No. 2700-0042

Small Business Innovation Research

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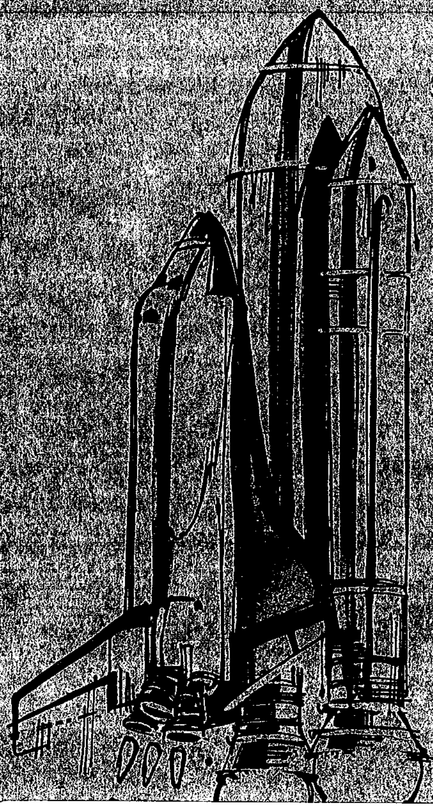

Program Solicitation

Closing Date: June 19, 1987

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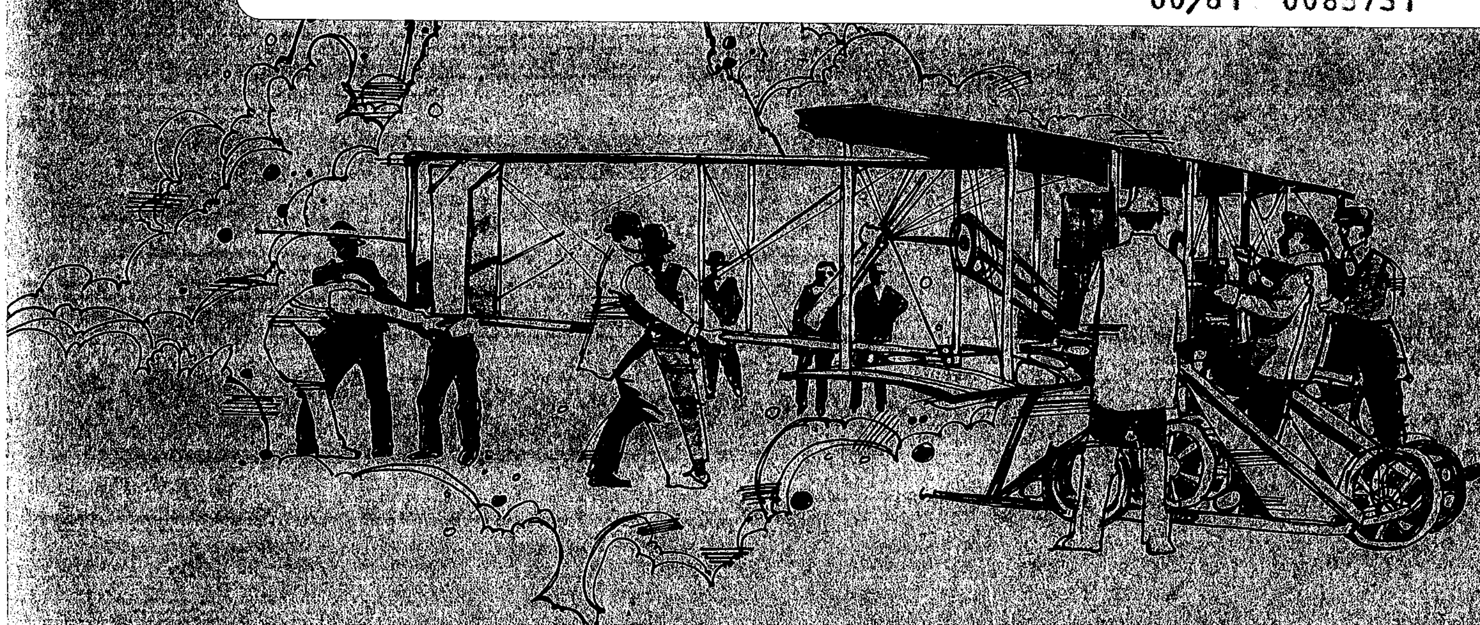

NASA

SBIR PROGRAM
WASHINGTON, D.C.
20546

August 24, 1987

Per telephone conversation with Mr. Johnson, NASA Headquarters, Code IR: Process in 7N-series.

French

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration (NASA) plans, directs, and conducts civil research and development in space and aeronautics.

NASA's goals in space are to develop technology to make operations more effective, to enlarge the range of practical applications of space technology and data, and to investigate the Earth and its immediate surroundings, the natural bodies in our solar system, and the origins and physical processes of the universe. In aeronautics, NASA seeks to improve aerodynamics, structures, engines, and overall performance of aircraft, to make them more efficient, more compatible with the environment, and safer.

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PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction and Summary

The National Aeronautics and Space Administration (NASA) invites small business firms to submit Phase I proposals under this Small Business Innovation Research (SBIR) program solicitation. This, the fifth annual SBIR solicitation by NASA, describes the program, identifies eligibility requirements, outlines proposal preparation and submission requirements, describes the proposal evaluation and award selection process, and provides other information to assist those interested in participating in NASA's SBIR program. It also identifies, in Section 8.0 and Appendix D, the specific Technical Topics and Subtopics in which SBIR Phase I proposals are solicited in 1987.

Firms with strong research capabilities in science or engineering in any of the areas listed are encouraged to participate. NASA expects to select approximately 170 high-quality research or research and development (R/R&D) proposals for Phase I contract awards based on this solicitation. Phase I contracts are for six months duration and may be funded up to $50,000, including profit. Selections will be based on the merit of the offering and on NASA needs and priorities.

For planning purpose only, NASA anticipates that approximately 50 percent of the Phase I projects—those showing greatest promise at the conclusion of Phase I—will be selected competitively for further development in Phase II continuations. The Phase II period of performance and funding will depend on the project scope, but will normally not exceed 24 months and $500,000. Only those Phase I contractors selected from this solicitation will be eligible to compete for Phase II continuations of their Phase I programs.

1.2 Three-Phase SBIR Program

The "Small Business Innovation Development Act of 1982," 15 U.S.C. 638, P.L. 97-219, was enacted July 22, 1982, and implemented by SBA Policy Directive No. 65 01.2 dated September 1984. NASA is one of the agencies conducting SBIR programs under the legislation. SBIR program objectives include stimulating technological innovation in the private sector, strengthening the role of small business in meeting Federal research and development needs, increasing the commercial application of Federally supported research results, and fostering and encouraging participation by minority and disadvantaged persons in technological innovation.

Participating agencies establish SBIR programs by reserving a statutory percentage of their extramural research and development budgets to be awarded to small business concerns for R/R&D during the first two phases of a uniform, three-phase process identified below. Each agency, at its sole discretion, selects the Technical Topics and Subtopics included in its Solicitation, chooses its SBIR awardees, and may decide to make several awards or no awards at all under any Subtopic.

The funding instruments used by NASA in both Phase I and Phase II programs are contracts rather than grants or cooperative agreements.

Phase I. Project objectives are to establish the feasibility and merit of an innovative scientific or technical concept proposed in response to an agency need or opportunity stated in a subtopic of this solicitation. Programs may be experimental or theoretical in nature.

In order to reduce the investment of time and cost to small firms in preparing a formal proposal under this solicitation, the *entire Phase I proposal is limited to 25 pages, including all forms and any attachments or enclosures.* The proposal should concentrate on means to demonstrate or otherwise establish the scientific or technical feasibility of the proposed innovation. Such evidence is a prerequisite for further NASA support in Phase II.

Selection criteria, which are described in Section 4.2, consider the scientific/technical merit of proposals including innovativeness, originality and relevance to important NASA scientific or engineering problems and opportunities; qualifications of the small business to conduct the proposed research; prospects for significant public benefit if the research is successful; and merit of the proposed work plan.

Phase I funding agreements with NASA are fixed-price, level-of-effort (FP/LOE) term contract awards. Simplified contract documentation is employed. Since price competition is not a factor in Phase I, the basis of selection among the best proposals will be those offering the greatest value to the Government in terms of the stated evaluation criteria.

Successful offerors will usually have six months and up to $50,000 to carry out their proposed Phase I efforts within the time period set for meeting the Phase II proposal evaluation and selection schedule. Phase I results must be submitted in a final report which will also support the Phase II proposal if one is submitted.

Phase II. This SBIR phase is the principal research effort. Only the Phase I contractors selected from the offerors responding to this solicitation will be eligible to compete for and participate in Phase II continuations of their programs. Phase II awards are expected to be made during 1988 to firms whose progress during Phase I was sufficiently promising to warrant further NASA support. Phase II awards may be for as much as $500,000 and cover a period usually not exceeding 24 months.

Phase II proposals are more comprehensive than those required for Phase I, and they are prepared in accordance with instructions provided to all Phase I contractors by the contracting NASA Field Installations after the Phase I contracts are awarded. Selection for Phase II awards is based on the criteria outlined in Section 4.3, including technical and scientific merit and feasibility of the proposed R/R&D; the results of the Phase I work; the project value to the NASA mission; the validity of the project plan for achieving stated goals; the capabilities of the project team and the availability of required equipment and facilities. Selections also depend, of course, on the availability of Federal Government funds.

When Phase II proposals are of equal technical and scientific merit, NASA will give special consideration to those which demonstrate non-Federal capital commitments for Phase III activities.

Phase III. This activity, where appropriate, is conducted by a small business using non-Federal capital to pursue commercial applications based on its Government-funded SBIR activities through Phase II. Phase III may also involve non-SBIR funded follow-on R/R&D or production contracts with a Federal agency for potential products or processes intended for use by the U.S. Government. Non-Federal capital commitments should be obtained prior to the submission of Phase II proposals, if possible, since they can be Phase II award selection considerations, as noted above.

1.3 Eligibility

Each offeror must qualify as a Small Business for R/R&D purposes as stated in Section 2.2. SBIR eligibility *does not* require that the offeror qualify as a Small Disadvantaged Business (Section 2.3) or as a Women-Owned Small Business (Section 2.6). In addition, the primary employment of the principal investigator must be with the small business firm at the time of contract award and during the proposed research, and the principal investigator must, in fact, work on and contribute significantly to the project if selected for award. Also, for both Phases I and II, the R/R&D must be performed in the United States (see Section 2.5).

The proposed innovation must be relevant to a NASA program need or opportunity identified in a subtopic listed in Appendix D of this solicitation, and it may be submitted under only one subtopic (see Section 5.14-e). Proposals must be prepared within the general format and physical requirements described under Section 3.

Proposals that do not meet all of the stated requirements in this solicitation and proposals from ineligible offerors will be rejected without consideration.

1.4 General Information

a. **Questions about this solicitation**: Oral communications regarding this solicitation during the Phase I proposal preparation period are restricted for reasons of competitive fairness, therefore no telephone inquiries will be accepted. Any and all questions pertaining to this solicitation must be submitted in writing to the address below:

   Mr. John A. Glaab
   SBIR Program Manager
   Code IR
   National Aeronautics and Space Administration
   Washington, DC 20546

b. **Additional copies of this solicitation** can be ordered by writing the SBIR Program Manager at the address listed above. No telephone requests will be accepted.

c. **Questions regarding proposal status**: Evaluation of proposals and selection of proposals for contract award will require approximately four to six months, and no information on proposal status will be available until the final selection is made (except for confirmation of receipt of proposal as described and limited in Section 6.5).

d. **Questions about the SBIR Program:** General questions about the NASA SBIR Program, but not pertaining to this solicitation or to requests for copies, may be submitted to either Harry W. Johnson, SBIR Director, or John A. Glaab, SBIR Program Manager, at the above address, telephone 202-453-8702. If telephoning, please do so between 10:00 a.m. and 4:00 p.m., EDT.

e. **Scientific and technical information:** Information on NASA R/R&D programs at any NASA Field Installation may be obtained by contacting the SBIR Manager at the Installation. *Please do not make inquiries relative to specific proposal preparations during the Phase I proposal preparation period.*

2.0 DEFINITIONS

The following definitions apply for purposes of this solicitation:

2.1 Research or Research and Development (R/R&D)—Any activity that is (1) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied, (2) a systematic study directed specifically toward applying new knowledge to meet a recognized need, or (3) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

2.2 Small Business—A concern that, at the time of award of Phase I and Phase II—

a. Is independently owned and operated, is organized for profit, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States;
b. Is at least 51 percent owned, or, in case of a publicly owned business, at least 51 percent of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens; and
c. Has, including its affiliates, a number of employees not exceeding 500 and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns, other than investment companies licensed, or state development companies qualifying under the Small Business Investment Act of 1958, 15 U.S.C. 661, et seq., are affiliates of one another when, either directly or indirectly, (1) one concern controls or has the power to control the other or (2) a third party controls or has the power to control both. Control can be exercised through common ownership, common management, and contractual relationships. The term "affiliates" is defined in greater detail in 13 CFR 121.3(a). The term "number of employees" is defined in 13 CFR 121.2(b). Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association or cooperative.

2.3 Small Disadvantaged Business Concern—A small business concern that (1) is at least 51 percent owned by one or more individuals who are both socially and economically disadvantaged, or a publicly owned business having at least 51 percent of its stock owned by one or more socially and economically disadvantaged individuals, and (2) has its management and daily business controlled by one or more such individuals.

Minority and disadvantaged individuals include members of any of the following groups: Black Americans; Hispanic Americans; Native Americans (American Indians, Eskimos, Aleuts, and native Hawaiians); Asian-Pacific Americans; or Asian-Indian Americans.

2.4 Subcontract—Any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government contractor calling for supplies or services required solely for the performance of the original contract.

2.5 United States—The several states, the District of Columbia, the Territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands.

2.6 Women-Owned Small Business—A small business that is at least 51 percent owned by a woman or women who also control and operate it. "Control" in this context, means exercising the power to make policy decisions. "Operate" in this context, means being actively involved in day-to-day management.

3.0 PHASE I PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 Proposal Requirements

The purpose of a proposal under the SBIR Program is to provide sufficient information to persuade NASA that the proposed work represents a sound approach to the investigation of an important scientific or engineering innovation of interest to NASA and is worthy of support under the stated criteria.

A proposal should be self-contained and written with the care and thoroughness accorded papers for publication. Each proposal should be reviewed carefully by the offeror to ensure inclusion of data essential for evaluation, using the check list (Appendix E).

The scientific or technical merit of the proposed innovation is the primary concern for all research supported by SBIR. A proposal may respond to any one of the subtopics in Appendix D, but must be limited to only one subtopic (see Section 5.14-e). The proposed R/R&D must be responsive to NASA program objectives, and it can also serve as the basis for technological innovation leading to new commercial products, processes, or services which benefit the public.

Proposals must be confined principally to research requiring scientific or technical innovation R/R&D, and they may lead to construction and evaluation of a laboratory prototype where appropriate. Proposals concerned principally with market research or the development of new or proven concepts (proprietary or otherwise, including patents) for commercialization should not be submitted. Such activities are considered responsibilities of the private sector, and are included in Phase III objectives. Neither should proposals be submitted for the development of processes or hardware for NASA use that are not based on significant innovation: such proposals may be considered only outside the SBIR program, either as unsolicited proposals or in response to specific solicitations.

3.2 General Content

Those who wish to respond to this solicitation should submit a research proposal as follows:

a. The proposal must be directed principally at R/R&D on a specific innovation which addresses a NASA need or opportunity chosen from one of the subtopics in Appendix D.

b. Phase I SBIR proposals shall not exceed a total of 25 standard 8-1/2" x 11" pages including cover page, project summary, project elaboration and supporting material, budget, and all enclosures or attachments. Each page shall be numbered consecutively at the center, bottom. *Proposals exceeding the 25 page limitation may be rejected without consideration.* No type size is to be smaller than elite except as legends on reduced drawings, but not tables. Pages are to be printed on one side only, single or double spaced.

c. The proposal should be direct, concise, and informative. Promotional and non-project-related material should not be included. Offerors should use the entire 25 page allowance only if required; appropriate brevity facilitates proposal evaluations.

d. All required items of information are to be covered fully and in the order set forth in Section 3.3, but the space allocated to each will depend on the project chosen and the principal investigator's approach. In the interest of equity to all offerors, all information must be included in the 25 pages; no additional attachments are allowed.

e. To facilitate proposal processing, NASA intends to employ automated optical devices to record proposal cover sheet and project summary information wherever possible. Toward this end, it is desirable, *but not required*, that the proposal cover sheet (Appendix A) and the project summary (Appendix B) be typed very carefully on the indicated lines, using one of the following type styles, using black ribbon:

   COURIER 12 10 or 12 PITCH
   COURIER 72 10 PITCH
   ELITE 72
   LETTER GOTHIC 10 or 12 PITCH
   OCR-B 10 or 12 PITCH
   PICA 72 10 PITCH
   PRESTIGE ELITE 10 or 12 PITCH
   PRESTIGE PICA 10 PITCH

f. To assist both NASA and the offeror, a Check-List is included (Appendix E). *It is to be filled out and attached to the original cover and project summary pages required in Section 6.1.* The Check List is not counted as a proposal page.

3.3 Phase I Proposal Format

a. **Cover Sheet.** The offeror shall complete Appendix A as page 1 of each copy of each proposal. No other cover is permitted.

b. **Project Summary.** The offeror shall complete Appendix B as page 2 of each proposal. The technical abstract should include a brief description of the problem or opportunity, the innovation, project objectives, and description of the effort. In summarizing anticipated results, the implications of the approach (for both Phases I and II) and the potential commercial applications of the research shall be stated. *The project summary of successful proposals will be published by NASA and, therefore, must not contain proprietary information.*

c. **Technical Content.** Beginning on page 3 of the proposal, include the following:

1. **Identification and Significance of the Innovation.** *The first paragraph shall contain a clear and succinct statement of the specific innovation proposed, why it is an innovation, and how it is relevant and important to meeting the need or opportunity described in the subtopic.* Appropriate background and any necessary elaboration of the proposed innovation should also be included in this section.

2. **Phase I Technical Objectives.** The offeror shall state the specific objectives of the Phase I R/R&D effort, including the technical questions it will try to answer to determine the feasibility of the proposed approach. *Proprietary information shall not be included in this section. The Technical Objectives and Work Plan will be included in the contract of successful offerors as the Statement of Work.*

3. **Phase I Work Plan.** The offeror shall include a detailed description of the Phase I R/R&D plan. The plan should indicate not only what will be done, but how and where the research or R&D will be carried out. Phase I R/R&D should address the stated objectives and the questions cited in (2) above. The methods planned to achieve each objective or task should be discussed in detail. This section should be approximately one-third of the total proposal. In every proposal, the Phase I Work Plan must be a complete, stand-alone document. *Proprietary data shall not be included in this section. If the offeror believes that proprietary data must be included in the proposal, it shall be included in a separate section entitled "Proprietary Addendum to Phase I Work Plan," and the requirement of Section 5.4-a, Proprietary Information, must be met to insure protection.*

4. **Related Research or R&D.** The purpose of this section is to persuade reviewers of the offeror's awareness of key recent developments by others in the specific subject area. It should describe any significant R/R&D that is directly related to the proposal (noting any conducted by the principal investigator or by the offeror's firm) including how it relates to the proposed effort, and any planned coordination with outside sources.

5. **Key Personnel and Bibliography of Directly Related Work.** The offeror shall identify key personnel involved in Phase I, including their directly related education, experience, and bibliographic information. Offerors are requested to avoid extensive vitae and publication lists not pertinent to the proposal. Summaries that focus on the most relevant experience or publications are desired, but must be contained within the 25-page limit.

6. **Relationship with Future Research and R&D.** The offeror shall state the anticipated results of the proposed approach if the project is successful (Phase I and Phase II), and discuss the significance of the Phase I effort in providing a foundation for Phase II. The expected scope of the Phase II activity should be outlined.

7. **Facilities.** The conduct of advanced research may require the use of sophisticated instrumentation or other equipment. Offerors should provide a detailed description, and discuss the availability and location, of instrumentation and physical facilities necessary to carry out Phase I.

8. **Consultants.** Involvement of expert consultants in the planning and research stages of the project is permitted and encouraged if this increases the probability of success of the proposed effort. If such involvement is intended, it should be described in detail.

9. **Potential Applications.** Offerors should describe briefly whether and by what means the proposed project appears to have potential (a) commercial application, and (b) use by the Federal Government.

10. **Related Proposals or Awards.** Whenever the offeror (a) has received Federal Government awards for related work, or (b) has elected to submit proposals for essentially equivalent or similar work under other Federal Government program solicitations, those awards and proposals shall be identified. In these cases, a statement must be included in each proposal indicating –

(1) The name and address of agencies to which proposals were submitted or from which awards were received.
(2) Date of proposal submission or date of award.
(3) Title, number, and date of solicitations under which proposals were submitted or awards received.
(4) The specific research topic for each proposal submitted or awards received.
(5) Titles of research projects.
(6) Name and title of principal investigator for each proposal submitted or award received.

If no such awards have been received, or proposals submitted, the offeror shall so state. Intentions to submit such proposals to other agencies in the near future should also be stated here.

d. **Proposed Budget.** Offerors shall complete Appendix C, then include it and any budget explanation sheets as the last page(s) of the proposal. Some items of this form may not apply to the proposed project and need not be filled out. What matters is that enough information be provided to allow NASA to understand how the offeror plans to use the requested funds if the contract is awarded.

- Equipment may be included in SBIR budgets. The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research proposed. Equipment is defined as an article of non-expendable, tangible, personal property having a useful life of more than one year and an acquisition cost of $1,000 or more per unit. Title to all property (including equipment) acquired under the contract will be vested with NASA unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the property by NASA.
- Budgets for travel funds must be justified and related to the needs of the project.
- A profit or fee may be included in the proposed budget.

Note: Detailed instructions for completing Appendixes A, B, and C are printed on their reverse sides.

4.0 PROPOSAL EVALUATION AND SELECTION

4.1 Evaluation, Selection, and Debriefing.

Phase I proposal evaluations involve several steps, the first of which is screening for compliance with administrative requirements of the Solicitation. All those found acceptable are next reviewed to determine whether they respond to the subtopic chosen by the offeror. Those found to be responsive will be evaluated by scientists or engineers in the topic area, using the criteria listed in Section 4.2. Each proposal will be judged on its own merit, then ranked relative to all others evaluated under the same subtopic. Reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any experiments referred to but not described in referenced professional journals. Relevant journal articles should be identified in the proposal.

Proposals may be evaluated at more than one NASA installation. Proposals judged to have the highest merit and value to NASA will be selected for award. Selection considerations will also include program balance and possible duplication of other research. In the evaluation and handling of proposals, NASA will make every effort to protect the confidentiality of the proposals and their evaluations.

Phase II proposals will also undergo a technical review and competitive selection process using specified Phase II criteria, which include the results of the Phase I activities (see Section 4.3).

After final Phase I and Phase II award decisions have been announced, a debriefing of an unsuccessful offeror's proposal may be provided—to the offeror only—upon written request. The identity of reviewers and their verbatim comments will not be disclosed.

4.2 Evaluation Criteria—Phase I

NASA plans to select proposals for award which offer the best value to the Government, giving approximately equal consideration to each of the following four criteria except for the first, which will receive twice the value of any other item:

a. **The scientific/technical merit** of: (1) the proposed innovation and its relevance to the needs stated in the selected subtopic, and (2) the proposal's statement of objectives and approach for addressing questions of feasibility. Special emphasis is given to innovativeness and originality.

b. **Qualifications** of the principal investigator, other key staff, and consultants, if any, and the adequacy of available or obtainable instrumentation and facilities.

c. **Anticipated benefits,** technical and/or economic, including the potential for commercial applications of the proposed Phase I and Phase II research if successful.

d. **Soundness and technical merit of the proposed work plan** and its incremental progress toward meeting the Phase I objectives.

4.3 Evaluation Criteria—Phase II

The NASA installations awarding the Phase I contracts will provide detailed instructions to all Phase I contractors regarding Phase II proposal submission, the relative importance of the evaluation factors listed below, and the date when Phase II proposals must be submitted (usually, one month after the end of the Phase I performance period). Evaluation of proposals for Phase II will consider the technical and scientific merit and feasibility of the proposed R&D (with special emphasis on its innovation and originality); the results of the Phase I work; the eventual value of the product, process, or technology to the mission of NASA; the validity of the project plan for achieving stated goals; the ability of the project team; and the availability of required equipment and facilities.

For proposals of approximately equivalent merit judged according to the criteria listed above, NASA will give special consideration to Phase II proposals which cite valid non-Federal capital commitments for Phase III follow-on activities. Valid commitments may be contingent on the outcome of Phase II (and on other circumstances), but must provide that a specific amount will be made available to the firm for Phase III and indicate the source and date or conditions under which the funds will be made available.

In addition, the selection of awards for Phase II will consider any special programmatic or schedule needs of NASA and, of course, the availability of funds. NASA has the right to initiate negotiations for a Phase II award at any time.

5.0 CONSIDERATIONS

5.1 Awards

In October 1987, NASA expects to announce the selection of approximately 170 proposals for negotiation of profit-bearing, fixed-price, level-of-effort term Phase I contracts with values ranging up to $50,000. Following contract negotiations and awards, Phase I contractors will usually have six months to carry out their proposed Phase I programs.

For planning purposes only, NASA anticipates that during 1988 approximately 50 percent of the Phase I projects may be selected for Phase II continuations, based on the results of Phase I activities and competitive evaluations of Phase II proposals. Funding agreements may be either fixed-price or cost-plus-fixed fee contracts. Performance periods normally will not exceed 24 months with funding not exceeding $500,000.

Both Phase I and Phase II awards are subject to availability of funds.

5.2 Reports

Six (original plus five (5)) copies of a final report on the Phase I project must be submitted to NASA within 30 days after completion of the Phase I effort. The final report shall include a single-page project summary as the first page, identifying the purpose of the research, a brief description of the research carried out, the research findings or results, and potential applications of the research in a final paragraph. The project summary is to be submitted without restriction and may be published by NASA. The balance of the report should indicate in detail the project objectives, work carried out, results obtained, and estimates of technical feasibility. Rights to this data shall be in accordance with the policies set forth in Section 5.5.

To avoid duplication of effort, language used in the Phase I report may be used verbatim in the Phase II proposal.

5.3 Payment Schedule

Payments on Phase I contracts may be vouchered as follows: one-third at the time of award, one-third three months after award, and the remainder upon acceptance of the final report by NASA. Payments will be made 30 days after receipt of valid vouchers or invoices.

5.4 Treatment and Protection of Proposal Information

a. **Proprietary Information.** It is NASA policy to use information (data) included in proposals for evaluation purposes only and to protect such information from unauthorized use or disclosure. While this policy does not require that the proposal bear a notice, protection can be assured only to the extent that an appropriate "Notice" is applied to the data which constitute trade secrets or other information that is commercial or financial and confidential or privileged. Other information may be afforded protection to the extent permitted by law, but NASA assumes no liability for use and disclosure of information to which the "Notice" has not been appropriately applied. To assure such protection, the offeror is advised to complete the proprietary notice at the bottom of the cover page (proposal page 1) of the proposal.

b. **Outside Reviewers.** In addition to Government personnel, NASA, at its discretion, may utilize scientists and engineers from outside the Government in the proposal review process. Any decision to obtain outside evaluation shall take into consideration requirements for the avoidance of organizational or personal conflicts of interest and the competitive relationship, if any, between the prospective contractor or subcontractor and the prospective outside evaluator. Any such evaluation will be under agreement with the evaluator that the information (data) contained in the proposal will be used only for evaluation purposes and will not be further disclosed.

c. **Release of Proposal Information.** It is NASA's practice to notify the submittor of the proposal before releasing any information (data) contained therein pursuant to a request under the Freedom of Information Act (5 U.S.C. 552) and, time permitting, to consult with the submittor to obtain assistance in determining the eligibility of the information (data) in question as an exemption under the Act.

d. **Nominal Disclosure.** By submission of a proposal, the offeror agrees to permit the Government to disclose only the title of its proposed project and the name, address and telephone number of the designated official of the proposing firm, to firms that may be interested in contacting the offeror for further information or possible investment.

5.5 Rights in Data Developed Under SBIR Contracts

Rights to data used in, or first produced under, any Phase I or Phase II contract will be specified in appropriate clauses in such contracts, consistent with the following:

a. Some data of a general nature are to be furnished to NASA without restriction (i.e., with unlimited rights) and may be published by NASA. These data will normally be limited to the project summary accompanying any periodic progress reports and the final report required to be submitted (see Section 5.2) but, in any event, the requirement for them will be specifically set forth in any contract resulting from this solicitation.

b. In keeping with NASA's policy, data that constitute trade secrets or other information that is commercial or financial and confidential or privileged and *developed at private expense* will not normally be acquired, but if acquired will be with "limited rights" or "restricted rights." Such rights do not include the right to use the data for manufacturing or reprocurement purposes.

c. Other than as required by (a) above, rights in technical data including software developed under the terms of any funding agreement resulting from proposals submitted in response to this solicitation shall remain with the contractor, except that the Government shall have the limited right to use such data for Government purposes and shall not release such data outside the Government without permission of the contractor for a period of two years from completion of the project from which the data were generated. However, effective at the conclusion of the two-year period, the Government shall retain a royalty-free license for Government use of any technical data delivered under an SBIR contract whether patented or not, but (except per (b) above) is relieved of all disclosure prohibitions and assumes no liability for unauthorized use of the data by third parties.

5.6 Copyrights

Contractors will be permitted to assert or establish claim to copyright data first produced under a Phase I or Phase II contract, subject to a paid-up, nonexclusive, irrevocable, worldwide license for Governmental purposes. The contractor is required to include an appropriate credit line acknowledging Government support for any works published under copyrights.

5.7 Patents

The contractor will normally have first option to retain title to inventions made in the performance of any Phase I or Phase II contract in accordance with P.L. 96-517 (35 U.S.C. 200, et. seq.). This option is subject to the reservations and limitations, including a nonexclusive, royalty-free, irrevocable license in the Government and certain march-in rights to assure commercialization, as required by P.L. 96-517 and implementing regulations thereunder.

Whenever an invention is made and reported under any NASA contract, it is NASA policy to withhold such report from disclosure to the public and to use reasonable efforts to withhold other information which may disclose the invention (provided that NASA is notified of the information and the invention to which it relates) for a reasonable time to allow the contractor to obtain patent protection as authorized by Section 205 of P.L. 96-517 (35 U.S.C. 205).

5.8 Cost Sharing

Cost sharing is permitted for proposals under this Program Solicitation. However, cost sharing is not required, nor will it be a factor in proposal evaluation.

5.9 Profit or Fee

Both Phase I and Phase II SBIR contracts may include a profit or fee.

5.10 Joint Ventures and Limited Partnerships

Both joint ventures and limited partnerships are permitted, provided the entity created qualifies as a small business in accordance with the definition in Section 2.2.

5.11 Similar Proposals and Prior Work

If an offeror has submitted to another Federal agency (or to NASA in a separate submission) a proposal which is substantially the same as, or similar in intent to one being submitted in response to this solicitation, that fact must be indicated and the information provided as required in Section 3.3.c-10.

If an award is made pursuant to a proposal submitted under this Program Solicitation, the firm will be required to certify that it has not previously been, nor is currently being, paid for essentially equivalent work by any agency of the Government.

5.12 Limitation on Research and Analytical Work

For Phase I, a minimum of two-thirds of the research and/or analytical effort must be performed by the proposing firm unless otherwise approved in writing by the contracting officer.

For Phase II, a minimum of one-half of the research and/or analytical effort must be performed by the proposing firm.

5.13 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of numerous clauses in the Phase I contract. The outline that follows illustrates the types of clauses that will be included in the Phase I contract. This is not a complete list of clauses to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

a. **Standards of Work.** Work performed under the contract must conform to high professional standards. Analyses, equipment, and components for use by NASA will require special consideration to satisfy the stringent safety and reliability requirements imposed in aerospace applications.
b. **Inspection.** Work performed under the contract is subject to government inspection and evaluation at all reasonable times.
c. **Examination of Records.** The Comptroller General (or a duly authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to the contract.
d. **Default.** The Government may terminate the contract if the contractor fails to perform the contracted work.
e. **Termination for Convenience.** The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.
f. **Disputes.** Any dispute concerning the contract that cannot be resolved by mutual agreement shall be decided by the contracting officer with right of appeal.
g. **Contract Work Hours.** The contractor may not require an employee to work more than 40 hours a week unless the employee is compensated accordingly (that is, receives overtime pay).
h. **Equal Opportunity.** The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex or national origin.
i. **Affirmative Action for Veterans.** The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era.
j. **Affirmative Action for Handicapped.** The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
k. **Officials Not to Benefit.** No member of or delegate to Congress shall benefit from the contract.
l. **Covenant Against Contingent Fees.** No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.
m. **Gratuities.** The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.
n. **Patent Infringement.** The contractor shall report to NASA each notice or claim of patent infringement based on the performance of the contract.

5.14 Additional Information

a. **Precedence of Contract over Solicitation.** This Program Solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR contract, the terms of the contract are controlling.
b. **Evidence of Contractor Responsibility.** Before award of an SBIR contract, the Government may request the offeror to submit certain organizational, management, personnel, and financial information to assure responsibility of the offeror.
c. **Limitations on Awards.** This solicitation is not an offer by the Government to make any specific number of awards under either Phase I or Phase II. NASA is not responsible for any monies expended by the offeror before award of any contract resulting from this solicitation. Also, awards under this Program Solicitation 87-1 are contingent upon the availability of funds.
d. **Consultants.** Consulting or other arrangements between eligible small business and universities or other nonprofit organizations are permitted with the small business serving as the prime contractor.
e. **Multiple Proposal Submissions.** An offeror may submit any number of different proposals on different subtopics, or different proposals on the same subtopic. However, every proposal must be

limited to one subtopic. Should the offeror consider a proposal to have relevance to more than one subtopic, the offeror must choose the one under which to submit the proposal. Within that proposal, the discussion of the innovation may identify other subtopics for which the concept is believed relevant; however, *such identification will not insure that the proposal will be evaluated within any subtopic other than the one to which the proposal is addressed. Offerors should be aware that identical or substantially similar proposals submitted to two or more subtopics will be rejected without consideration.*

f. **Classified Proposals.** NASA will not accept classified proposals.

g. **Unsolicited Proposals.** The SBIR Program is not a substitute for existing unsolicited-proposal mechanisms. Unsolicited proposals will not be accepted under the SBIR program in either Phase I or Phase II.

6.0 SUBMISSION OF PROPOSALS

6.1 What to Send

For each proposal submitted, offerors must submit the following:

a. Five (5) copies of the proposal, complete with cover sheet, project summary and proposed budget,
b. The original (red) cover sheet (Appendix A), bearing the original signatures of the principal investigator and an official empowered to commit the offeror. Copies attached to each of the proposal copies may be suitably reproduced.
c. The original (red) Project Summary (Appendix B). Copies attached to each of the proposal copies may be suitably reproduced.
d. The completed Check List (Appendix E).

6.2 Physical Packaging Requirements

Bindings—Do not use bindings or special covers. Staple the pages in the upper left-hand corner of each proposal.

Packaging—All items (6.1 a through d) for each proposal must be sent in the same package. If more than one proposal is being submitted, it is requested that all proposals be sent in the same package whenever possible.

6.3 Where to Send Proposals

Proposals shall be addressed as below:

SBIR Program Manager
Code IR
National Aeronautics and Space Administration
(Note: No street address is required)
Washington, DC 20546

Handcarried proposals should be delivered to Room A16, Federal Office Building 10B, NASA Headquarters, 600 Independence Avenue, SW, Washington, DC. Secure packaging is mandatory. NASA cannot be responsible for the processing of proposals damaged in transit.

6.4 Deadline for Proposal Receipt

Deadline for receipt of proposals at NASA is 4:00 p.m., EDT, June 19, 1987. NASA assumes no responsibility for evaluating proposals received after the stated deadline or that do not adhere to other requirements of this solicitation. Offerors are cautioned to be careful of unforseen delays that can cause late arrival of proposals at NASA with the result that they may not be included in the evaluation process. Notwithstanding, NASA reserves the right to consider proposals or modifications thereof received after the date indicated for receipt of proposals, and also the right to consider a revision to an otherwise successful proposal received after the date indicated for receipt of proposals should such actions be in the best interests of the Government.

6.5 Acknowledgement of Proposal Receipt

NASA will acknowledge receipt of proposals by a special card mailed to the company official endorsing the proposal cover sheet. If a proposal acknowledgement card is not received from NASA within four weeks following the closing date of this solicitation, the offeror should telephone 202-453-8702. NASA will not accept telephone inquiries of acknowledgement of receipt of proposals prior to July 17, 1987.

6.6 Withdrawal of Proposals

Proposals may be withdrawn by written notice or telegram (including mailgram) received at any time before award. Proposals may be withdrawn in person by an offeror or an authorized representative, if the representative's identity is made known and the representative signs a receipt for the proposal before award.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

The following organizations can provide technology search and/or document services and can be contacted directly for service and cost information. These include:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

Aerospace Research Applications Center
611 N. Capitol Avenue
Indianapolis, IN 46204
(317) 262-5003

Central Industrial Applications Center
Southeastern Oklahoma State University
Durant, OK 74701
(405) 924-6822

NASA/Southern Technology Applications Center (STAC)
State University System of Florida
307 Weil Hall
Gainesville, FL 32611
(904) 392-6626

North Carolina Science and Technology Research Center
Post Office Box 12235
Research Triangle Park, NC 27709
(919) 549-0671

NASA Industrial Applications Center
823 William Pitt Union
University of Pittsburgh
Pittsburgh, PA 15260
(412) 648-7000

NASA/UK Technology Applications Program
University of Kentucky
109 Kinkead Hall
Lexington, KY 40506-0057
(606) 257-6322

New England Research Application Center (NERAC)
Mansfield Professional Park
Storrs, CT 06268
(203) 429-3000

NASA Industrial Application Center
University of Southern California
3716 S. Hope Street - Rm 200
Los Angeles, CA 90007
(213) 743-6132
(800) 642-2872 California only
(800) 872-7477 Toll free U.S.

8.0 TECHNICAL TOPICS

Proposals shall address subtopics in Appendix D under the following technical topics:

01.00 Aeronautical Propulsion and Power
02.00 Aerodynamics and Acoustics
03.00 Aircraft Systems, Subsystems, and Operations
04.00 Materials and Structures
05.00 Teleoperators and Robotics
06.00 Computer Sciences and Applications
07.00 Information Systems and Data Handling
08.00 Instrumentation and Sensors
09.00 Spacecraft Systems and Subsystems
10.00 Space Power
11.00 Space Propulsion
12.00 Human Habitability and Biology in Space
13.00 Quality Assurance, Safety, and Check-Out for Ground and Space Operations
14.00 Satellite and Space Systems Communications
15.00 Materials Processing, Micro-Gravity, and Commercial Applications in Space

APPENDIX A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SBIR SOLICITATION PROPOSAL COVER

		PROPOSAL NUMBER (TO BE COMPLETED BY PROPOSER)			
		4 DIGIT SUBTOPIC NUMBER	LAST 4 DIGITS OF FIRM PHONE NO.	CHANGE LETTER	
<T>	87-1 <★>	___ . ___	______	_____	ENTER PROPOSAL NUMBER ON APPENDICES B & C

PROJECT TITLE <★> ____

____

FIRM NAME <★> ____

MAIL ADDRESS <★> ____

CITY <★> ____________________ STATE <★> ______ ZIP CODE <★> ____________

AMOUNT REQUESTED <★> $ __________ (PHASE I) DURATION <★> ______ MONTHS (PHASE I)

OFFEROR CERTIFIES THAT:

	YES	NO
1. As defined in Section 2 of the Solicitation, this firm qualifies as a:		
1.1 Small business	☐	☐
1.2 Minority and disadvantaged small business	☐	☐
1.3 Women-owned small business	☐	☐
NOTE: 1.2 and 1.3 are not eligibility requirements for SBIR and the offeror may decline to indicate status by stating "Decline" across boxes.		
2. A minimum of two-thirds of the research and/or analytical effort for this project will be carried out within the firm if an award is made.	☐	☐
3. The primary employment of the principal investigator will be with this firm at the time of award and during the conduct of the research.	☐	☐
4. If the proposal does not result in an award, NASA is authorized to disclose to interested parties the proposal title and the name, address and telephone number of the Corporate Official signator below.	☐	☐
5. If proprietary information is submitted it is included in a Proprietary Addendum, and the Proprietary Notice (below) is checked.	☐	☐
6. Proposals of similar content have (indicate Yes) or have not (indicate No) been submitted to another agency and the details required by Section 5.11 of the Solicitation are included in the proposal.	☐	☐

ENDORSEMENTS

	Principal Investigator	Corporate/Business Official
Typed Name <★>	____________________	<★> ____________________
Title <★>	____________________	<★> ____________________
Telephone No. <★>	____________________	<★> ____________________

Signature of Principal Investigator ____________________ Date __________

Signature of Corporate/Business Official ____________________ Date __________

PROPRIETARY NOTICE (IF APPLICABLE, SEE SECTION 4.4.3.C & 6.5)

NOTICE: The information (data) on pages __________ of this proposal constitute a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes; provided, however, in the event a contract is awarded on this proposal, the Government may obtain additonal rights to use and disclose this information (data).

PROPOSAL PAGE 1

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Appendix A:

1. *Proposal Number.* Complete the proposal number as follows:
   a. Enter 4 digit subtopic number (do not insert the period).
   b. Enter the last four digits of your firm's telephone number.
   c. If you are submitting different proposals under the same subtopic, enter a change letter as appropriate to differentiate proposal numbers.

Example: 1. Firm, telephone 273-8126, submits one proposal to subtopic 06.03. Proposal number is: *0603 8126*.

Example: 2. Firm, telephone 392-4826, submits three different proposals to subtopic 11.03. Proposal numbers are:

1103 4826
1103 4826A
1103 4826B

2. *Project Title:* Enter a brief, descriptive title using no more than 80 keystrokes (characters and spaces). Do not use the subtopic title.
3. *Firm Name:* Enter full name of company submitting the proposal. If a joint venture, list company chosen to negotiate and receive contracts. If name exceeds 30 keystrokes, please abbreviate.
4. *Address:* Enter mail address.
   State: Enter 2 letter state designation (example Maine — ME)
   Zip-Code: Enter 5 or 9 digit code
5. *Amount Requested:* Enter proposal amount from budget summary. Round to nearest dollar. *Do not* enter cents.
6. *Duration:* Enter proposed duration in months. If the proposed duration is other than 6 months, be sure to discuss reason in the text of the proposal.
7. *Certifications:* Enter Y for yes or N for no in the appropriate boxes in response to the statements or questions.
8. *Endorsements:* The proposal should be signed by the proposed principal investigator *and* an official of the firm qualified to make a contractual commitment on behalf of the firm. The PI and the Corporate Official may be the same person.

Appendix B:

1. *Proposal Number:* Enter the proposal number developed for your proposal.
2. *Title of Project:* Enter the same title as shown on your Proposal Cover.
3. *Technical Abstract:* Provide a summary of 200 words or less of your proposed project. The abstract must not contain proprietary information.
4. *Potential Commercial Applications of the Research:* Summarize the commercial potential of the project assuming the results of the proposed research or R&D are achieved.
5. *Key Words:* Provide no more than 8 key words descriptive of the project and useful in identifying the technology, research thrust or application of the proposed effort.
6. *Name and Address of Offeror:* Enter firm name and mail address as shown on the Cover Sheet.
7. *Principal Investigator:* Enter name of the Principal Investigator as shown on the Cover Sheet.

APPENDIX A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SBIR SOLICITATION PROPOSAL COVER

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<T>	87-1 <★>	___ . ___	______	_____

ENTER PROPOSAL NUMBER ON APPENDICES B & C

PROJECT TITLE <★> ____

____

FIRM NAME <★> ____

MAIL ADDRESS <★> ____

CITY <★> ____________________ STATE <★> ______ ZIP CODE <★> ____________

AMOUNT REQUESTED <★> $ __________ (PHASE I) DURATION <★> ______ MONTHS (PHASE I)

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4. If the proposal does not result in an award, NASA is authorized to disclose to interested parties the proposal title and the name, address and telephone number of the Corporate Official signator below.	☐	☐
5. If proprietary information is submitted it is included in a Proprietary Addendum, and the Proprietary Notice (below) is checked.	☐	☐
6. Proposals of similar content have (indicate Yes) or have not (indicate No) been submitted to another agency and the details required by Section 5.11 of the Solicitation are included in the proposal.	☐	☐

ENDORSEMENTS

	Principal Investigator	Corporate/Business Official
Typed Name	<★> ____________________	<★> ____________________
Title	<★> ____________________	<★> ____________________
Telephone No.	<★> ____________________	<★> ____________________

Signature of Principal Investigator ____________________ Date __________

Signature of Corporate/Business Official ____________________ Date __________

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PROPOSAL
PAGE
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APPENDIX A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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PROJECT TITLE <★> ____

____

FIRM NAME <★> ____

MAIL ADDRESS <★> ____

CITY <★> ______________ STATE <★> ______ ZIP CODE <★> __________

AMOUNT REQUESTED <★> $ __________ (PHASE I) DURATION <★> ______ MONTHS (PHASE I)

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Title	<★> ____________________	<★> ____________________
Telephone No.	<★> ____________________	<★> ____________________

Signature of Principal Investigator ____________________ Date __________

Signature of Corporate/Business Official ____________________ Date __________

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APPENDIX B - PROJECT SUMMARY
(INSTRUCTIONS ON REVERSE SIDE)
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SBIR 87-1 SOLICITATION

TO BE COMPLETED BY PROPOSER

TOPIC • SUBTOPIC -4 TEL DIGITS - ALPHA (SEE INSTRUCTIONS)

PROPOSAL NO.: ___ ___ ___ . ___ ___ ___ ___ — ___ ___ ___ ___ ___ AMOUNT REQUESTED: $

TITLE OF PROJECT

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

POTENTIAL COMMERCIAL APPLICATIONS OF THE RESEARCH

KEY WORDS
(LIMIT 8)

NAME AND ADDRESS OF OFFEROR

PRINCIPAL INVESTIGATOR

PROPOSAL
PAGE
2

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3. *Firm Name:* Enter full name of company submitting the proposal. If a joint venture, list company chosen to negotiate and receive contracts. If name exceeds 30 keystrokes, please abbreviate.
4. *Address:* Enter mail address.
   State: Enter 2 letter state designation (example Maine — ME)
   Zip-Code: Enter 5 or 9 digit code
5. *Amount Requested:* Enter proposal amount from budget summary. Round to nearest dollar. *Do not* enter cents.
6. *Duration:* Enter proposed duration in months. If the proposed duration is other than 6 months, be sure to discuss reason in the text of the proposal.
7. *Certifications:* Enter Y for yes or N for no in the appropriate boxes in response to the statements or questions.
8. *Endorsements:* The proposal should be signed by the proposed principal investigator *and* an official of the firm qualified to make a contractual commitment on behalf of the firm. The PI and the Corporate Official may be the same person.

Appendix B:

1. *Proposal Number:* Enter the proposal number developed for your proposal.
2. *Title of Project:* Enter the same title as shown on your Proposal Cover.
3. *Technical Abstract:* Provide a summary of 200 words or less of your proposed project. The abstract must not contain proprietary information.
4. *Potential Commercial Applications of the Research:* Summarize the commercial potential of the project assuming the results of the proposed research or R&D are achieved.
5. *Key Words:* Provide no more than 8 key words descriptive of the project and useful in identifying the technology, research thrust or application of the proposed effort.
6. *Name and Address of Offeror:* Enter firm name and mail address as shown on the Cover Sheet.
7. *Principal Investigator:* Enter name of the Principal Investigator as shown on the Cover Sheet.

APPENDIX B - PROJECT SUMMARY
(INSTRUCTIONS ON REVERSE SIDE)
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SBIR 87-1 SOLICITATION

TO BE COMPLETED BY PROPOSER

TOPIC • SUBTOPIC -4 TEL DIGITS - ALPHA (SEE INSTRUCTIONS)

PROPOSAL NO.: ___ ___ ___ • ___ ___ ___ ___ – ___ ___ ___ ___ ___   AMOUNT REQUESTED: $

TITLE OF PROJECT

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

POTENTIAL COMMERCIAL APPLICATIONS OF THE RESEARCH

KEY WORDS
(LIMIT 8)

NAME AND ADDRESS OF OFFEROR

PRINCIPAL INVESTIGATOR

PROPOSAL
PAGE
2

INSTRUCTIONS FOR COMPLETING APPENDIX A AND APPENDIX B

General:

To facilitate proposal processing, NASA intends to employ automated optical devices to record proposal information wherever possible. Toward this end, it is desirable, but not required, that the proposal cover sheet (Appendix A) and the project summary (Appendix B) be typed without proportional spacing using one of the following typestyles:

Courier 12 10 or 12 pitch
Courier 72 10 pitch
Elite 72
Letter Gothic 10 or 12 pitch
OCR-B 10 or 12 pitch
Pica 72 10 pitch
Prestige Elite 10 or 12 pitch
Prestige Pica 10 pitch

Please complete and *submit the original red forms* bound in this solicitation (not photocopies). The completed forms can then be copied for use as pages 1 and 2 of your proposal. The original red forms should be submitted in addition to the five copies of your total proposal (see section 6.2 "Physical Packaging Requirements").

Carefully align the forms in the typewriter using the underlines as a guide. The forms are printed to accommodate standard typewriting spacing.

Appendix A:

1. *Proposal Number*. Complete the proposal number as follows:
   a. Enter 4 digit subtopic number (do not insert the period).
   b. Enter the last four digits of your firm's telephone number.
   c. If you are submitting different proposals under the same subtopic, enter a change letter as appropriate to differentiate proposal numbers.

Example: 1. Firm, telephone 273-8126, submits one proposal to subtopic 06.03. Proposal number is: *0603 8126*.

Example: 2. Firm, telephone 392-4826, submits three different proposals to subtopic 11.03. Proposal numbers are:

1103 4826
1103 4826A
1103 4826B

2. *Project Title:* Enter a brief, descriptive title using no more than 80 keystrokes (characters and spaces). Do not use the subtopic title.
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APPENDIX B - PROJECT SUMMARY
(INSTRUCTIONS ON REVERSE SIDE)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SBIR 87-1 SOLICITATION

TO BE COMPLETED BY PROPOSER

TOPIC • SUBTOPIC -4 TEL DIGITS - ALPHA (SEE INSTRUCTIONS)

PROPOSAL NO.: __ __ __ • __ __ __ __ — __ __ __ __ __ AMOUNT REQUESTED: $

TITLE OF PROJECT

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

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7. *Principal Investigator:* Enter name of the Principal Investigator as shown on the Cover Sheet.

APPENDIX C - SBIR PROPOSAL SUMMARY BUDGET
(INSTRUCTIONS ON REVERSE SIDE)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SBIR 87-1 SOLICITATION

FIRM: PROPOSAL NUMBER:

PRINCIPAL INVESTIGATOR:

(See Instructions on Back of Form) TOTAL PRICE

MATERIAL: $

PERSONNEL: $

OTHER DIRECT COSTS: $

OVERHEAD: $

GENERAL AND ADMINISTRATIVE (G&A): $

PROFIT: $

TOTAL PRICE PROPOSED $

TYPED NAME AND TITLE: SIGNATURE:

THIS PROPOSAL IS SUBMITTED IN RESPONSE TO NASA SBIR PROGRAM SOLICITATION 86-1 AND REFLECTS OUR BEST ESTIMATES AS OF THIS DATE. DATE SUBMITTED

PROPOSAL PAGE NO.

INSTRUCTIONS

The purpose of this form is to provide a vehicle whereby the offeror submits to the Government a pricing proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting system.

This summary does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, on a budget explanation page immediately following the budget in the proposal. (See below for discussion on various categories).

1. **MATERIALS —**
   a. *Materials and Supplies.* Indicate types required and estimate costs.
   b. *Publication Costs/Page Charges.* Estimate cost of preparing and publishing project results.
   c. *Consultant Services.* Indicate name, daily compensation, and estimated days of service.
   d. *Computer Services.* Include justification. Computer equipment leasing is included here. Purchase of equipment is included under OTHER DIRECT COSTS.
   e. *Subcontracts.* Include a completed budget and justify details.
   f. *Other.* Itemize and justify.
2. **PERSONNEL** — On the budget explanation page, list individually all personnel included, the requested person-months to be funded, and rates of pay (salary, wages, and fringe benefits).
3. **OTHER DIRECT COSTS** — List all other direct costs which are not otherwise included in the categories described above. For travel, address the type and extent of travel and its relation to the project. List each item of permanent equipment to be purchased, its price, and explain its relation to the project.
4. **OVERHEAD** — Specify current rate(s) and base(s). Use current rate(s) negotiated with the cognizant federal negotiating agency, if available. If no rate(s) has (have) been negotiated, a reasonable indirect cost (overhead) rate(s) may be requested for Phase I which will be subject to approval by NASA. If a current negotiated rate(s) is (are) not available for Phase II, NASA will negotiate an approved rate(s) with the contractor. Offerors may use whatever number and types of overhead rates that are in accordance with their accounting systems and approved by the cognizant federal negotiating agency, if available.
5. **GENERAL AND ADMINISTRATIVE (G&A)** — Specify current rate and base. Use current rate negotiated with the cognizant federal negotiating agency, if available. If no rate has been negotiated, a reasonable indirect cost (overhead) rate may be requested for Phase I which will be subject to approval by NASA. If a current negotiated rate is not available for Phase II, NASA will negotiate an approved rate with the contractor.

APPENDIX D
SUBTOPICS

FIELD CENTERS

TOPIC 01.00 AERONAUTICAL PROPULSION AND POWER

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
01.01							*		INTERNAL FLUID MECHANICS FOR AEROSPACE PROPULSION SYSTEMS
01.02							*		COMPONENTS FOR AEROPROPULSION SYSTEMS
01.03							*		INSTRUMENTATION, SENSORS AND CONTROLS FOR AEROPROPULSION SYSTEMS
01.04							*		HYPERSONIC PROPULSION
01.05							*		NOVEL PROPULSION CONCEPTS

TOPIC 02.00 AERODYNAMICS AND ACOUSTICS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
02.01	*							*	COMPUTATIONAL FLUID DYNAMICS
02.02						*			EXPERIMENTAL FLUID DYNAMICS
02.03						*			VISCOUS FLOWS
02.04						*			THEORETICAL AERODYNAMICS
02.05	*								TURBULENCE SIMULATION AND MODELING
02.06	*			*		*			HYPERSONIC AEROTHERMODYNAMICS
02.07								*	RAREFIED GAS DYNAMICS
02.08							*	*	VACUUM PLUME EFFECTS
02.09	*								CONFIGURATIONAL AERODYNAMICS INCLUDING VORTICES
02.10	*								ROTORCRAFT AERODYNAMICS AND DYNAMICS
02.11	*								PREDICTION METHODS FOR POWERED-LIFT VEHICLE AERODYNAMICS
02.12						*			AIRCRAFT NOISE

TOPIC 03.00 AIRCRAFT SYSTEMS, SUBSYSTEMS, AND OPERATIONS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
03.01							*		ICING AND ICE PROTECTION SYSTEMS
03.02						*			AIRCRAFT FLIGHT ENVIRONMENT
03.03	*					*			AERONAUTICAL FLIGHT MANAGEMENT AND HUMAN FACTORS
03.04	*								EXPERT SYSTEMS FOR AEROSPACE APPLICATIONS
03.05							*		CONTROL CONCEPTS FOR AIRCRAFT
03.06	*								AUTOMATIC GUIDANCE FOR ROTORCRAFT NAP-OF-THE-EARTH FLIGHT
03.07	*					*			AIRCRAFT FLIGHT TESTING TECHNIQUES AND INSTRUMENTATION
03.08						*			HYPERSONIC FLIGHT SYSTEMS TECHNOLOGY

TOPIC 04.00 MATERIALS AND STRUCTURES

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
04.01							*		COMPOSITE MATERIALS STRUCTURES FOR AEROSPACE PROPULSION
04.02						*			COMPOSITE MATERIALS FOR NON-PROPULSION STRUCTURAL APPLICATIONS
04.03						*	*		STRUCTURAL METALLICS FOR AEROSPACE APPLICATIONS
04.04							*		INTELLIGENT AUTOMATED STRUCTURAL DESIGN OPTIMIZATION
04.05				*				*	SPACE STRUCTURES CONCEPTS AND MATERIALS
04.06		*							SPECIALIZED MATERIALS FOR SPACE FLIGHT APPLICATIONS
04.07					*				SPECIALIZED MATERIALS FOR LAUNCH SITE FACILITIES
04.08								*	WELDING TECHNOLOGY
04.09	*								THERMAL PROTECTION MATERIALS
04.10			*						STRUCTURAL DESIGNS FOR FUTURE NASA SPACE MISSIONS
04.11			*						REDUCED WEIGHT GONDOLAS FOR STRATOSPHERIC BALLOONS
04.12				*					LUNAR MATERIALS UTILIZATION

TOPIC 05.00 TELEOPERATORS AND ROBOTICS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
05.01		*	*			*			TELEROBOTIC TECHNOLOGY
05.02				*				*	ARTIFICIAL INTELLIGENCE FOR SPACE STATION APPLICATIONS
05.03							*		SERVO-DRIVE MECHANISMS FOR ROBOTIC MANIPULATORS
05.04			*						TELESCIENCE
05.05			*						MARTIAN SURFACE SAMPLE ACQUISITION, PROCESSING, AND EARTH RETURN

TOPIC 06.00 COMPUTER SCIENCES AND APPLICATIONS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
06.01						*			ENGINEERING COMPUTER SCIENCE
06.02		*			*	*			AUTOMATED SOFTWARE DEVELOPMENT AND MAINTENANCE
06.03	*				*				KNOWLEDGE UNDERSTANDING, REPRESENTATION, AND IMPLEMENTATION
06.04			*						KNOWLEDGE-BASE TECHNOLOGY FOR SOFTWARE COMPONENTS
06.05				*					SOFTWARE SYSTEMS FOR MISSION PLANNING AND FLIGHT CONTROL
06.06			*		*				INTEGRATED CAD/CAE AND KNOWLEDGE-BASED SYSTEMS
06.07	*								COMPUTER SCIENCES ADVANCES IN SUPPORT OF COMPUTATIONAL PHYSICS

TOPIC 07.00 INFORMATION SYSTEMS AND DATA HANDLING

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
07.01						*			FOCAL-PLANE IMAGE PROCESSING
07.02		*							SPACECRAFT OPERATIONS AND DATA MANAGEMENT
07.03		*							SIGNAL AND INFORMATION PROCESSING
07.04		*							MANAGEMENT INFORMATION COMMUNICATIONS
07.05		*							GROUND-BASED DATA MANAGEMENT SYSTEMS
07.06		*							HETEROGENEOUS DISTRIBUTED DATABASE MANAGEMENT
07.07			*						SOFTWARE/WORK STATION DEVELOPMENT FOR REMOTELY SENSED DATA
07.08		*							IMAGE ANALYSIS TECHNIQUES
07.09	*								SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)

TOPIC 08.00 INSTRUMENTATION AND SENSORS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
08.01			*						PLANETARY, EARTH SENSING AND ASTROPHYSICS INSTRUMENTATION
08.02		*							EARTH SENSING FROM SPACE
08.03	*								HIGH RESOLUTION REMOTE SENSING FOR EARTH OBSERVATIONS
08.04	*								GLOBAL BIOLOGY SENSORS
08.05			*						OCEANOGRAPHIC INSTRUMENTS AND SOFTWARE
08.06			*						INSTRUMENTS FOR GEOLOGICAL RESEARCH
08.07		*							SPECTRORADIOMETRIC STANDARDS FOR ULTRAVIOLET REMOTE SENSING
08.08						*			TUNABLE SOLID STATE LASERS, DETECTORS AND LIDAR SUBSYSTEMS
08.09						*			SENSORS FOR ATMOSPHERIC AEROSOLS
08.10								*	ATMOSPHERIC MEASUREMENTS AND ANALYSES IN MANNED SPACE MISSIONS
08.11		*							BEHAVIOR AND EFFECTS OF CONTAMINATION IN SPACE
08.12	*								INFRARED TECHNOLOGY FOR ASTRONOMICAL APPLICATIONS
08.13	*								EXOBIOLOGICAL ANALYSIS OF COSMIC DUST
08.14			*						SPACECRAFT INSTRUMENTS
08.15		*							INSTRUMENT POWER DISTRIBUTION AND CONTROL
08.16		*							DETECTORS AND DETECTOR ARRAYS
08.17			*						FOCAL PLANE ARRAY PROCESSING FOR POSITION DETERMINATIONS
08.18			*						SUBMILLIMETER RADIOMETER AND ANTENNAS
08.19		*							OPTICAL COMPONENTS AND SYSTEMS
08.20	*					*			WIND TUNNEL INSTRUMENTATION
08.21								*	AEROHEATING FLIGHT INSTRUMENTATION

TOPIC 09.00 SPACECRAFT SYSTEMS AND SUBSYSTEMS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
09.01						*			CONTROL OF LARGE SPACE STRUCTURES
09.02				*					SPACE CONSTRUCTION AND MAINTENANCE TOOLS AND TECHNIQUES
09.03				*					SPACE STATION CREW WORKSTATION DISPLAYS AND CONTROLS
09.04				*				*	MANNED SPACECRAFT AND PLANETARY BASE THERMAL MANAGEMENT SYSTEMS
09.05		*						*	THERMAL CONTROL FOR UNMANNED SPACE APPLICATIONS
09.06				*					STS POWER CONTROL AND DISTRIBUTION SUBSYSTEMS
09.07				*					STS TRACKING SYSTEMS
09.08								*	TETHER APPLICATIONS IN SPACE
09.09		*							GAS, ELV AND SPARTAN SYSTEMS

TOPIC 10.00 SPACE POWER

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
10.01							*		LARGE SCALE SPACE POWER SYSTEMS
10.02							*		SPACECRAFT AND PLANETARY ROVER POWER/ENERGY SYSTEMS

TOPIC 11.00 SPACE PROPULSION

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
11.01								*	SOLID ROCKET MOTOR TECHNOLOGY
11.02							*		HIGH PERFORMANCE, LONG LIFE, SMALL CHEMICAL ROCKETS
11.03								*	ROCKET ENGINE COMBUSTION PROCESSES
11.04								*	LIQUID ENGINE INTERNAL FLOW DYNAMICS
11.05								*	EXPERIMENTAL FLUID DYNAMICS OF ROCKET ENGINES

TOPIC 12.00 HUMAN HABITABILITY AND BIOLOGY IN SPACE

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
12.01				*					ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS
12.02								*	WASTE WATER RECLAMATION AND MONITORING FOR SPACE STATION
12.03				*					MEDICAL SCIENCES FOR MANNED SPACE PROGRAMS
12.04				*					HUMAN FACTORS FOR SPACE CREWS
12.05				*					INTRAVEHICULAR SYSTEMS FOR SPACE CREWS
12.06	*								ANIMAL AND PLANT LIFE SUPPORT AND PROTECTIVE SYSTEMS
12.07					*				BIOLOGICAL SCIENCES OPERATIONS

TOPIC 13.00 QUALITY ASSURANCE, SAFETY AND CHECK-OUT FOR GROUND AND SPACE OPERATIONS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
13.01				*	*				GROUND OPERATIONS INSTRUMENTATION
13.02					*				GROUND CHECKOUT COMMUNICATIONS
13.03					*				LAUNCH PROCESSING QUALITY ASSURANCE TECHNOLOGY
13.04					*				ROBOTIC GROUND PROCESSING OF SPACE SYSTEMS AND COMPONENTS
13.05					*				PRODUCTION AND HANDLING OF AEROSPACE FUELS AND PROPELLANTS
13.06								*	FLOW MEASUREMENT DEVICE FOR GROUND TEST AND CHECKOUT
13.07					*	*			NONDESTRUCTIVE EVALUATION
13.08					*				LAUNCH AND LANDING SITE WEATHER

TOPIC 14.00 SATELLITE AND SPACE SYSTEMS APPLICATIONS

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
14.01							*		ADVANCED COMMUNICATIONS SATELLITE SYSTEMS
14.02			*						SATELLITE-BASED MOBILE VOICE AND DATA COMMUNICATION SERVICES
14.03							*		MONOLITHIC DISTRESS BEACON
14.04		*		*					COMMUNICATIONS FOR MANNED SPACE SYSTEMS
14.05			*						MULTIPLE FUNCTION ANTENNA FEED
14.06			*						OPTICAL COMMUNICATIONS FOR DEEP SPACE

TOPIC 15.00 COMMERCIAL APPLICATIONS IN SPACE

	ARC	GSFC	JPL	JSC	KSC	LaRC	LeRC	MSFC	
15.01							*	*	MATERIALS PROCESSING IN SPACE
15.02							*		SOLIDIFICATION PROCESSING CONCEPTS
15.03							*		MICROGRAVITY SCIENCE, TECHNOLOGY AND ENGINEERING EXPERIMENTS
15.04						*			CHEMICAL VAPOR DEPOSITION ANALYSIS AND MODELING TOOLS
15.05				*					REDUCED GRAVITY PROCESS CHEMISTRY
15.06	*								LIFE SCIENCE COMMERCIAL RESEARCH AND APPLICATIONS IN SPACE

LEGEND:

ARC - Ames Research Center
Moffett Field, CA

GSFC - Goddard Space Flight Center
Greenbelt, MD

JPL - Jet Propulsion Laboratory
Pasadena, CA

JSC - Johnson Space Center
Houston, TX

KSC - Kennedy Space Center
Kennedy Space Center, FL

LaRC - Langley Research Center
Hampton, VA

LeRC - Lewis Research Center
Cleveland, OH

MSFC - Marshall Space Flight Center
Huntsville, AL

SUBTOPIC DESCRIPTIONS

TOPIC 01.00 AERONAUTICAL PROPULSION AND POWER

01.01 Subtopic: Internal Fluid Mechanics for Aerospace Propulsion Systems

Center: LeRC

Innovative techniques are sought for analyzing flows in aerospace propulsion systems:

- Internal computational mechanics: Application of parallel processors, expert systems, innovative graphics, and scientific database structures, etc. Accurate numerical methods for fixed grid density and increased convergence rates. Strategies for multiblock grids and zonal approaches combining two or more numerical methods. Geometry (3-D) and mesh generation techniques for complex surface description, grid-lattice construction, and solution adaptive mesh clustering. Turbulent 3-D flow codes with new turbulence models.
- Inlets and nozzles: Advanced steady-state and time-dependent flow analyses and benchmark data for low subsonic through hypersonic speeds, for component and systems performance, boundary layers, bleed flows, diffusion, jet mixing, separated flow, heat transfer, surface cooling, and external spillage.
- Fans and compressors: Advanced numerical flow field codes, physical models, and supporting validation data for unsteady flows, blade-row interactions, rotor shocks, viscous flows on blades and endwalls and secondary flows for advanced compression systems, including single and multistage axial, centrifugal, and mixed flow fans and compressors. Novel concepts for instrumentation and flow visualization.
- Combustors and augmentors: Efficient computer models, and innovative means to supply validation data for the flows, physical processes, and reaction mechanisms in a combustor including fuel injection, spray evaporation and mixing, and basic reaction mechanisms and kinetic rates for hydrocarbon oxidation and soot formation.
- Turbines: Innovations to improve life, performance and reliability of large and small turbines for aircraft and aerospace application. Rigorous three-dimensional viscous flow models and subroutines for full passage codes that include heat transfer, unsteady flow, rotation, accurate treatment of boundary layer phenomena, and rotor blade tip clearance flows.
- Space fluid mechanisms: To make modern Internal Computational Fluid Mechanics a working computational tool which can accelerate fundamental understanding of space-based processes, new capability needs to be demonstrated. Opportunities include fluid behavior, thermal and combustion processes in low earth orbit; advanced thermal control and cryogenic fluid management for Space Station; and parallel processing and knowledge based systems technologies applicable to space-based power and propulsion.

01.02 Subtopic: Components for Aeropropulsion Systems

Center: LeRC

Innovations are sought in four areas: turbine engines, rotary combustion engines, drive train technology, and advanced propellers.

- Turbine engines: Innovative design concepts are needed for more efficient fans, compressors, turbines and combustors applicable to "small" sizes including:
  —Innovative concepts to improve cycle efficiency;
  —Advanced materials to minimize or eliminate coolant penalties;
  —Concepts for recuperators/regenerators which minimize weight, volume, and aerodynamic drag through innovative design and/or use of advanced materials.;
- Rotary combustion engines: Advanced, innovative components, material and subsystems are sought for rotary combustion engines (RCEs) capable of burning jet fuel with high efficiency and specific power, light weight and low vibration, including:
  —High-speed, high BMEP multi-fuel combustion system elements, including advanced fuel injection/ignition methods;
  —Advanced seals, bearings and lubricants for high output RCE;
  —Advanced materials and fabrication technology for lightweight and/or heat-resistant (insulative) structural components, such as rotors and trochoid and end housings;
  —Advanced turbocharger/turbocompounding in the 0.5 to 5 lb/sec flow range having single stage pressure ratios of 5 to 8:1.
- Drive train technology: New concepts are needed to decrease drive system weight and noise and to increase reliability and strength such as:
  —Lubricants to extend operation temperatures of gear boxes to beyond 200C;
  —Gear and bearing materials to extend operating temperatures beyond 200C;
  —Transmission health monitoring systems;

—New tooth forms for lower noise and better lubricant action;
—New transmission concepts for large transmissions;
—Transmission noise prediction methods;
—Elastohydrodynamic film thickness predictive methods for bevel gear sets;
—Expert systems and optimization methods for gear and transmission design.

- Advanced propellers: Propellers designed for flight speeds up to mach 0.8 require innovative design approaches to maintain high efficiency, low noise and structural integrity. New or improved concepts and analytical and experimental verification methods are needed. Specific needs include:
—Aerodynamic analysis and design methods and diagnostic or flow visualization methods;
—Methods for calculating and diagnosing mechanisms of noise generation and propagation;
—Unsteady flow analysis methods to predict aerodynamic forces, fluctuating pressures on installed blades as input to acoustic calculations and the occurrence of flutter;
—Approaches to achieve goals of increased efficiency, reduced noise, improved flutter margin, and lower weight;
—Fabrication techniques for improved strength and weight.

01.03 Subtopic: Instrumentation, Sensors and Controls for Aeropropulsion Systems
Center: LeRC

The accurate measurement of pressure, temperature, strain, flow, and other parameters is important both to the design of advanced aerospace propulsion systems and to the operation and control of these systems in aerospace vehicles. The mathematical models used by designers must be verified with accurate data obtained during benchmark experiments. Therefore, advanced non-intrusive or minimally intrusive instrumentation and diagnostic techniques are required as an essential part of propulsion system development programs. In addition, the increased thermal and aerodynamic loads to which propulsion system components are exposed require more precise measurement of the hostile operating environment and the engine condition for control, safety, and health monitoring considerations. Innovations in advanced high durability, high temperature, and precise sensors and instrument systems are needed in both aeronautical and space applications.

- Strain and temperature on both metal and ceramic surfaces (for up to 1900C operation).
- Gas temperatures and pressures, both static and dynamic (for up to 1900C operation).
- Fiber-optic-based sensors and control systems.
- Aerodynamic flow and turbulence measurements.
- Blade tip clearance measurement systems for turbine and compressors.
- Non-intrusive combustion and rocket plume diagnostics.

Improved performance and operability of propulsion systems and subsystems or components through the use of real-time intelligence in closed loop control is required. The basic premise is that powerful onboard computing capability and new sensor technology will make possible optimized engine performance and life by incorporating feedback control.
Innovative approaches are sought in:

- Nonlinear or adaptive real-time control design for propulsion systems.
- Reliability enhancement through redundancy management or fault detection for propulsion systems.
- Improved component performance via compressor stall alleviation or combustor pattern factor control.
- Integrated system intelligence.

01.04 Subtopic: Hypersonic Propulsion
Center: LeRC

New concepts are needed for advancing the state of the art for hypersonic (mach 5 and higher) airbreathing propulsion systems. Examples of innovations sought include:

- Advanced materials concepts to provide the low density (below 0.2 lb/cu. in.) with high temperature (above 2200F) retention of properties. The materials should provide high modulus, low thermal expansion, high thermal conductivity, and must be amenable to fabrication into complex structures for hypersonic applications.
- Innovative computational methods to improve understanding of flow phenomena associated with hypersonic propulsion devices, including inlets, ejectors, combustors, and nozzles.
- Fundamental analytical studies leading to an understanding of ignition, flame holding, and flame stability for supersonic/hypersonic combustion.
- Advanced high-temperature structural sealing concepts for articulating engine panel-sidewall seals (sliding seals between moving and stationary engine panels) and panel-hinge seals (sealing the hinge line between two neighboring engine panels), and computational methods to assess performance (e.g., determine seal temperatures and leakage rates, etc.) and optimize structural seal concepts based on seal geometry and materials, seal operating environ-

ment, seal coolant techniques (e.g., regenerative, film, transpiration), coolant fluid and flow rates.

01.05 Subtopic: Novel Propulsion Concepts
Center: LeRC

Major improvements in propulsion system performance weight, bulk, and cost are cornerstones of many important future aeronautical vehicles, especially viable high-speed accelerators for transatmospheric vehicles and efficient cruise powerplants for super/hypersonic airplanes. Identification and analyses of innovative propulsion system concepts are sought that promise revolutionary advances in vehicle capabilities. Examples of existing concepts include: supersonic through-flow fans, supersonic combustion ramjets, and beamed energy. The analyses sought include first-order system concept modeling and/or comparative evaluations against conventional powerplant baselines or other advanced alternatives, but not specific detailed component characterizations.

TOPIC 02.00 AERODYNAMICS AND ACOUSTICS

02.01 Subtopic: Computational Fluid Dynamics
Centers: ARC
MSFC

More powerful numerical computation capabilities for predicting fundamental fluid flow phenomena can lead to improved aerodynamic characteristics and overall configurational optimization for advanced aircraft, missiles and aerospace vehicles of every type and application. NASA's interest in computational fluid dynamics encompasses the entire spectrum of real gas aerothermodynamic phenomena which may be encountered by aircraft and aerospace vehicles from subsonic to hypersonic speeds, including static and dynamic behavior, transient phenomena, maneuvering, stability and control, aerodynamic performance, heating and heat transfer. Applications include both external and internal flow fields and multiple body interactions including stores and separation effects. Innovations are sought in every activity related to CFD, including, for example:

- Numerical method innovations for solving the fluid flow equations which increase computational efficiency, accuracy, speed and utility. These include construction of new algorithms, improved computer languages, improved geometric modeling, advanced component-adaptive grid operation methods and other innovative techniques.
- Innovative analytical, numerical, and experimental techniques that enhance the understanding of turbulence and provide improved models for solving the Navier-Stokes equations. These include improved turbulence models, large-eddy simulation for high Reynolds number flows, numerical methods for full- and large-eddy simulation, improved subgrid-scale models for large-eddy simulations, turbulence models applicable to aerodynamic flows with massive separation and wakes.
- Correlation of ground facility and flight data for fundamental aerothermodynamic performance characteristics of advanced aerospace vehicles.

02.02 Subtopic: Experimental Fluid Dynamics
Center: LaRC

This subtopic addresses the need for experimental techniques to advance our understanding of aerodynamic phenomena. Desired innovations include:

- Test section design for transonic wind tunnels to reduce wall interference, reduce power requirements, and improve flow quality.
- Method to study ground effect and transition aerodynamics of models of V/STOL aircraft in wind tunnels.
- Method to extract dynamic-stability data from wind tunnel models suspended magnetically.
- Method to simulate propulsion effects for wind tunnel models suspended magnetically.
- Cost-effective way to recover liquid nitrogen from the exhaust of cryogenic wind tunnels. (Exhaust gas is nitrogen at temperatures from 80K to 300K and pressures from 1.2 to 9 atmospheres.)
- Method to suppress noise and turbulence caused by flow disturbances in wind tunnels.
- Statistical method to detect anomalies in wind tunnel data either during or after the test. The method should allow user definition of the list of anomalies.
- Automated on-line analysis of unsteady pressure data to provide boundary layer transition location.

02.03 Subtopic: Viscous Flows
Center: LaRC

Innovative methods for predicting and controlling laminar and turbulent viscous flows are desired. Primary emphasis for turbulent flow is on controlling the behavior of turbulent shear flows including boundary layers, free-shear layers, and recirculating vortex flows. The specific needs are:

- Innovative methods and devices for control of turbulence.

- Techniques for turbulent skin friction reduction.
- Improved understanding through theory and/or new measurement techniques of the physics and structure of turbulent shear flows.

02.04 Subtopic: Theoretical Aerodynamics
Center: LaRC

Innovative theoretical approaches are required to gain an understanding of a broad spectrum of existing and emerging problems associated with the aerodynamic design and analysis of advanced aircraft configurations. New or improved analysis techniques, theoretical studies, and conceptual models are desired for configuration design aerodynamics; for fundamental aerodynamic problems such as high-speed-shock/boundary-layer interaction and real gaseffects; and for evaluating and correcting for facility interference effects. Specific needs include the following areas:

- New concepts and techniques to achieve more efficient coupling of 3-D viscous-inviscid interactions at high Reynolds number.
- Theoretical tools to study boundary-layer stability and transition to turbulence.
- Theoretical approaches to turbulence modeling with emphasis on massively separated flows.
- New concepts for the evaluation and correction of wind tunnel interference, particularly at transonic speeds and high angles of attack.
- Improved models for wing leading-edge vortex flows and vortex wakes; techniques for vortex drag reduction.
- Improved methods for solving stiff partial-differential equations governing fluid phenomena.
- Advanced methods for the design of airfoils and multielement airfoils for high lift and low drag.
- Innovative approaches are needed to predict unsteady aerodynamic loads, including viscous, rotational and vortex flow effects, on complex aircraft configurations; novel techniques that integrate aerodynamic analysis methods with structural models also are desired.

02.05 Subtopic: Turbulence Simulation and Modeling
Center: ARC

Innovative analytical, numerical, and experimental techniques that enhance the understanding of turbulence and provide improved models are required for solving the Navier-Stokes equations. To support the goal of NASA's program to greatly improve capabilities in aeronautical simulation, innovations in the following areas are sought:

- Improved turbulence models.
- Large eddy simulation for high Reynolds number flows.
- Numerical methods for full- and large-eddy simulation.
- Improved subgrid-scale models for large-eddy simulations.
- Turbulence models applicable to aerodynamic flows with massive separation and wakes.

02.06 Subtopic: Hypersonic Aerothermodynamics
Centers: ARC
JSC
LaRC

In addition to innovative concepts in computational and experimental aero/fluid dynamics which are solicited in related subtopics, this subtopic solicits innovations of special applicability to the understanding and prediction of hypersonic aerothermodynamic phenomena needed in the design and development of future vehicles such as second generation Shuttle, Aero-assist Orbital Transfer Vehicle (AOTV), the National Aerospace Plane (NASP), hypersonic re-entry vehicles, future planetary probes and hypersonic transport aircraft. Areas of interest for analytical and experimental innovation include, but are not limited to, the following:

- Adding real gas physics to existing and future numerical schemes.
- Gas/surface interactions and chemical energy accommodation.
- Radiation and rates associated with excitation of radiation.
- Equilibrium and finite-rate chemistry flows.
- Transport properties and multi-component mixing laws.
- Chemical kinetic rates.
- Turbulence modeling and simulation.
- Experiments to guide development of model equations and verify benchmark computer codes.
- High velocity and high-temperature experimental techniques, including methodology for radiative and non-equilibrium flows.

02.07 Subtopic: Rarefied Gas Dynamics
Center: MSFC

Innovative improvements are sought in methods for predicting rarefied gas dynamic phenomena. Of particular importance are Aero- and aerothermal loads prediction techniques for aeromaneuvering and aerobraking vehicles during high altitude (rarefied) operations, including:

- Inclusion of radiation production and transfer from weakly ionized gases in Monte Carlo flowfield simulations;

- Wake closure, impingement and heating on payloads shielded by an aerobrake, in both ideal gas and real gas hypersonic flow at low Reynolds numbers;
- Fast prediction of blunt face heating distributions, which include variable chemistry effects but which do not require the computational time of CFD codes.

02.08 Subtopic: Vacuum Plume Effects

Center: LeRC
MSFC

Prediction of plume impingement effects from microthrusters and vents on spacecraft and the Space Station which can cause contamination, affect thrust and aerodynamic stability, and impact viewing experiments. Better understanding is important both to thruster and vent design and their integration. Of particular interest are:

- Fully viscous nozzle/plume flow characteristics prediction methods including nonequilibrium processes in the transitional regime of the vacuum plume;
- Accurate and computationally efficient procedures to predict the transport of vacuum plume contamination to spacecraft or Space Station surfaces.

Large government test facilities (and computational capabilities) can be made available, if appropriate, for experimental measurements for validating analytical models.

02.09 Subtopic: Configurational Aerodynamics Including Vortices

Center: ARC

This subtopic solicits proposals of innovative concepts related to new and improved aerodynamic configurations for heavy transport aircraft, including but not limited to the following areas:

- Vortex flow devices and wing configurations to improve leading-edge extension and slender wing performance.
- Nozzle-afterbody integration.
- A new approach that does not rely on well-structured, body-fitted coordinate systems, for solving 3-D aircraft-configuration aerodynamic problems using the Euler and Navier-Stokes equations.
- Expeditious methods for handling the extremely large amounts of data produced in experimental and computational research on aircraft configurations. Special visualization techniques are required and may need development of specialized software and hardware.

The development of experimental methods and data analysis procedures to enhance the understanding of vortex-dominated flows would have important uses in boundary layer management, high-angle-of-attack aerodynamics, separated flows, rotor wake interactions, and vane-type vortex generators. Innovative experimental techniques using small-scale, laboratory-size facilities are needed to understand the interaction between vortices and boundary layers, shear layers, or solid surfaces. The extensive use of modern sensor technology and/or sophisticated computer-experiment integration is considered an important part of this area of interest.

02.10 Subtopic: Rotorcraft Aerodynamics and Dynamics

Center: ARC

Many aspects of rotorcraft aerodynamics and dynamics are not thoroughly understood or adequately modeled, and much remains to be done. Required are innovative methods which describe the basic phenomena involved in rotorcraft aerodynamics and dynamics, provide greater knowledge of the detailed characteristics of these phenomena, and permit well-verified accurate predictions to be made. Innovative developments with application to tilt rotors, single main rotor and tandem helicopters, co-axial helicopters, and rotors with circulation control (i.e., X-Wing type aircraft) are needed to refine the next-generation motorcraft. Examples of problems currently of importance include: aerodynamics of rotor-airframe-tail interactions; rotor blade air flow loading analyses; improved rotor system performance; analysis of advanced hub designs and their influence on rotor dynamics; rotorcraft vibration and vibration alleviation; aeroelastic stability; and rotor noise. Innovations in new rotor concepts would also be appropriate.

02.11 Subtopic: Prediction Methods for Powered-Lift Vehicle Aerodynamics

Center: ARC

Innovative methods for accurate prediction of the flow about powered-lift vehicles are desired. Problems to be addressed include:

- Flow separation effects due both to high angle-of-attack flight and lifting jets.
- Modeling of propulsion-airframe interaction concepts producing either direct or indirect thrust; i.e., thrust deflectors and ejectors.

Considerable ingenuity will be required to include viscous jets in the models and to define and conduct verification experiments.

Innovative concepts for powered-lift configurations and components are desired. Special interest is in concepts that utilize ejectors and provide favorable interactions with the lifting surfaces.

Research may be either theoretical, computational, experimental or a combination.

02.12 Subtopic: Aircraft Noise
Center: LaRC

The control of aircraft and helicopter noise involves sources such as jet exhausts, propellers, and rotors. For each significant noise source on a particular vehicle class, the noise generation mechanism must be understood, prediction methods must be available, and concepts for noise control must be in hand. Innovations are needed in:

- Aeroacoustic computational techniques for direct simulation of large scale structures in compressible flows for determining the near-field pressure and far-field acoustics of high performance propulsion systems and flight vehicles including hypersonic configurations.
- A micro-mechanical pressure sensing array using microelectronics fabrication technology to integrate the mechanical sensing elements and the supporting electronic circuits, with a nominal density of 20 sensing elements per inch, capable of measuring fluctuating pressures of 20 KHz with amplitudes between 3 and 3000 pascal.
- Improved atmospheric noise propagation models to include temperature gradients, uneven terrain, and winds.
- Improved understanding and prediction of the interaction of near field noise with boundary layers.
- New concepts for far field noise reduction of helicopter main rotor and tail rotor.
- Diagnostic techniques to identify and quantify important noise sources in aircraft interiors and noise paths including airborne and structureborne transmission paths.
- New concepts for reducing aircraft interior noise, including active control methods.
- New methods for predicting and experimentally determining sonic fatigue characteristics of advanced structural materials and configurations including high temperature effects and accelerated testing methods.

TOPIC 03.00 AIRCRAFT SYSTEMS, SUBSYSTEMS, AND OPERATIONS

03.01 Subtopic: Icing and Ice Protection Systems
Center: LeRC

Helicopters and general aviation aircraft need an all-weather capability. Advanced commercial transports will need ice protection systems compatible with high-bypass and turboprop engines (with small cores), modern airfoils and composite materials. Innovative solutions for aircraft icing problems are needed in four main areas:

- Methods for predicting ice accretion on unprotected surface and the resultant aerodynamic penalties.
- Ice protection systems that minimize weight and power consumption, and design databases for these systems.
- Instrumentation for the detection and measurement of ice accretion and icing cloud properties.
- Instrumentation for detecting the changes in aircraft performance due to icing and for assessing, in real time, the icing threat.

03.02 Subtopic: Aircraft Flight Environment
Center: LaRC

This subtopic focuses on the effects of atmospheric processes on the design and efficient operation of aircraft. Innovations in experimental and analytical areas should improve predictability, detection and avoidance of severe storm hazards and provide a data base for safe design criteria for those hazards which cannot be avoided. Specific hazards to be considered are heavy rain, wind and wind shear, turbulence and in-flight lightning. Specific innovations are required in airborne equipment suitable for measuring environmental effects in flight and L-band telemetry receiving equipment. There is a need for instrumentation and flight environments. Analytical techniques are needed to predict severe storm hazards and aircraft performance effects.

Innovations are needed for assessing the effects of lightning on future advanced composite aircraft employing flight critical digital systems. Refined lightning characterization requires: modeling of lightning/aircraft interaction; development of techniques and methodology for interpretation and generalization of data for prediction of lightning interaction with aircraft; establishment of a statistical basis for generalized lightning environment based on interpretation methodology and direct strike data; and techniques for predicting lightning-induced effects on systems in advanced composite aircraft.

There is increasing interest in the development of an on-board aircraft sensor for the premonitory detection of low-altitude wind-shears such as those caused by microbursts occurring within airport terminal areas. Since a very large fraction of microbursts are known to have water droplets associated with their appropriate for handling this problem. Any useful radar design must cope, however, with difficult physical factors that lie beyond the capabilities of conventional airborne weather radars. Among these factors are the suppression of the effects of ground clutter, the achievement of adequate spatial resolution and the recognition of an unambiguous, quantitative "signature" associated with difficulties and to assist in the development of a practical and affordable airborne radar wind-shear sensor.

03.03 Subtopic: Aeronautical Flight Management and Human Factors

Centers: ARC
LaRC

In the face of advancing technology, the human pilot is becoming the most critical element in aircraft design and operation. This criticality is readily seen by examining aviation accidents and incidents: fully 80% of all such accidents and incidents are due to human error. Advances in avionics technology make it feasible to apply new computational equipment and devices to the flight deck, and to automate many crew functions. A major concern, however, is how to keep the crew properly involved in the flight management process as their role moves from that of an operator of the system to that of a manager of the system. To help facilitate the many flight management and safety objectives involved, innovative approaches are required for:

- Advanced crew-system interface concepts which improve the overall performance and reliability of the pilot-aircraft system, and insure efficient and safe use of ATC system technology.
- Concepts such as advanced, integrated visual displays, "expert" or "intelligent" systems that monitor status, aid, inform or advise the flight crew; and other advanced input and output devices and methods (voice synthesis and recognition, pointing, and touch devices); all of which have been proposed as means of increasing the effectiveness of the modern flight crew.
- The establishment of a quantitative and qualitative data base for display format/arrangement factors.
- The development and validation of human response measurement technologies for the assessment of aerospace crew mental state.
- The determination of single-pilot cockpit requirements for operation in an advanced ATC environment.
- The development of the basis for reliable substitution of simulators for research applications involving atmospheric environment factors.

Evaluations of the candidate technologies should include consideration of pilot information processing, decision making, and the cognitive workload associated with pilot performance. New concepts are also needed for models of pilot responses which encompass a broad range of human functions.

03.04 Subtopic: Expert Systems for Aerospace Applications

Center: ARC

Concurrent advances in computer design and computer science have established the knowledge-based expert system as a realistic alternative in computer-aided decision tools. Current activities in expert systems involve the development of application systems, the development of flexible expert system "shells" and artificial intelligence research that increases expert system performance (knowledge representation, learning, etc.). Efforts to date have addressed a diverse but restricted set of subject domains in order to demonstrate capabilities. Future expert systems must be flexible, reliable, and capable of being used for domains that have the complexity of typical real-world problems.

The purpose of this subtopic is to solicit novel, innovative, and relevant applications of knowledge-based systems, or the development of expert system building tools applicable to aerospace vehicles. All research that would apply within the broad scope of aerospace technology is eligible for support, though Space Shuttle and Space Station applications are excluded (they are covered within other subtopics). Areas of interest involve systems (whole or in part) that address the design, operation, survivability, maintainability, or other aspect of aerospace vehicles.

The proposer should be aware of any on-going research in similar areas as the proposed topic to avoid duplication and to enable statement of the relative advantages of funding such work. Proposals funded in previous years have addressed accident investigation, aircraft design and automatic fault diagnosis. Further proposals in these areas are not encouraged unless a unique approach is being considered. Research that provides results that can subsequently be used in aerospace applications (i.e., tools tailored for requirements unique to the aerospace domain) are also of interest.

03.05 Subtopic: Control Concepts for Aircraft

Center: LaRC

The traditional disciplines of aerodynamics, structures, propulsion and avionics are relying to an increased extent on advanced controls concepts for achieving enhanced mission performance and efficiency while expanding the aircraft flight envelope. This has led to a need to reexamine conventional control system design criteria and to develop synthesis methods for improving interactions and performance between complex aircraft dynamics, the pilot and the mission objectives. Areas of interest for innovative approaches and concepts include:

- Control theory.
- Flying and handling qualities.
- Active controls.
- Propulsion control.
- Real-time trajectory optimization.
- High angle-of-attack modeling and parameter extraction.
- Functional controls integration.

03.06 Subtopic: Automatic Guidance for Rotorcraft Nap-of-the-Earth Flight

Center: ARC

Nap-of-the-Earth (NOE) flight in a conventional helicopter is currently extremely taxing for two pilots under VFR conditions. Developing a single-pilot all-weather NOE capability will require significant automation. A major goal would be the development of a fully automatic NOE flight-control capability. The NOE flight regime requires the helicopter to fly below tree tops whenever possible, following a preplanned nominal trajectory. The automated flight-control systems may use a combination of advanced sensors for mapping out the vehicle's surrounding for obstacle detection. Innovative concepts are desired with the potential of providing an obstacle-avoidance guidance system that accepts the real-time obstacle information and issues maneuver commands to the autopilot. Potential technologies applicable to the development of such flight-control systems include state-of-the-art techniques in computer vision, sensor fusion/processing, advanced control concepts, various expert-system disciplines and graphics techniques for presentation of terrain information.

03.07 Subtopic: Aircraft Flight Testing Techniques and Instrumentation

Centers: ARC
LaRC

Sophisticated real-time measurement and analysis techniques are needed to extract aerodynamic, structural, and propulsion system characteristics in flight, as well as to safely expand the flight envelope of aeronautical vehicles. Innovative methods using both onboard and ground-based processing are sought to:

- Provide accurate real-time identification of structural mode characteristics.
- Measure thrust in flight for advanced turbojet or turboprop engines.
- Determine several aircraft performance parameters during integrated maneuvers.
- Estimate highly non-linear characteristics of aircraft and propulsion systems.
- Apply expert systems in real-time monitoring and control during flight test.
- Flight Research:
  —Smart angle-of-attack and angle-of-sideslip sensors;
  —Pressure sensors for external adaption over fuel tanks without disturbing air flow in thin boundary layers;
  —Miniature airborne dew point sensor with response sufficient for commercial aircraft ascent rates.

Innovative sensors and associated processing techniques are needed for measurements of

- Strain on advanced structures at temperatures of 1700C and above.
- Wide ranges of pressure at high temperatures in jet engines.
- Fuel flow to determine 1-2% differences in thrust.
- Strain on rotating propulsion system components.
- Structural deflections and shape dynamically in flight.

New, high-quality methods are needed for visualizing and characterizing local flow phenomena to determine location of vortex flows and laminar-to-turbulent flow transition in a wide variety of flight conditions.

03.08 Subtopic: Hypersonic Flight Systems Technology

Center: LaRC

New concepts in combined cycle engines, lightweight structural materials, cryogenic and high temperature insulation, subsystem components, and systems integration are emerging which make the vehicle dry weight fraction, propulsion and aerodynamic performance requirements of a true aerospace plane vehicle achievable. Ultimately, efficient commercial transportation will fly at more than 7 times the speed of today's airliners, and military vehicles will take off from conventional runways, fly to orbit, maneuver in space, and return.

Proposals for innovative concepts in the supporting technical disciplines are invited in other places in this solicitation, e.g., Topics 1, 2 and 4, and will not be considered in this subtopic. The purpose of this subtopic is to identify opportunities for systems-oriented innovations, including but not limited to the following:

- Optimization strategies applicable to component and vehicle geometry.

- Structural concepts for vacuum jacketed integral cryogenic tankage.
- Innovative thermal management approaches.

TOPIC 04.00 MATERIALS AND STRUCTURES

04.01 Subtopic: Composite Materials/Structures for Aerospace Propulsion

Center: LeRC

Advanced materials for aerospace propulsion and power applications offer many advantages in terms of cost, weight, and performance. Innovations are sought in all the following areas:

- Monolithic ceramic SiC and Si_3N_4 materials, higher reliability and reproducibility goals require:
  —Techniques for providing understanding of the relations among starting materials, processing parameters, microstructure, and properties including additions of toughening phases;
  —Powders and sintering aids which will provide more homogeneous microstructure of minimum flaws in both size and number;
  —Processing, e.g., modeling, sintering and hot isostatic pressing to minimize flaws, improve temperature capability and enhance fracture toughness.
- Ceramic matrix composite materials:
  —Ceramic-matrix composites of improved toughness and reliability;
  —Ceramic fibers of improved, high-temperature strength, purity and handle-ability;
  —Material models to predict and optimize ceramic performance based on matrix and fiber properties.
- Polymeric materials:
  —Polymer matrix composites and adhesives suitable for use at temperatures above 650K and amenable to design and fabrication using extensions of conventional technology including lower cure temperatures;
  —Optimization of process monitoring to allow adequate control and verification of chemistry changes during the fabrication of composite structures;
  —Computational methods for matrix resin molecular design and synthesis;
  —Materials models to predict matrix properties and also to predict composite properties based on matrix and fiber design.
- Laminated composite structures tailored to specific types of loads, temperatures, and reducing or oxidizing environments are also needed, and unique processes are sought such as hot pressing, explosive bonding, HIP diffusion bonding or a combination of several methods to core and layer these structures.

04.02 Subtopic: Composite Materials For Non-Propulsion Structural Applications

Center: LaRC

Processing of fiber-reinforced composite materials into consistent quality parts and development of advanced high-performance thermoplastic, thermosetting, and hybrid matrix composite systems requires in situ monitoring during cure cycle processing and thermoforming. Novel embedded sensors to monitor changes in matrix chemistry during processing are solicited.

Innovative approaches for fabricating low-cost, high-quality graphite reinforced metal-matrix composite materials into tubes and other elements of space structures are needed. Thin cross-sections are especially needed.

New approaches are required to achieve high-temperature metal-matrix composites for hypersonic airplanes. Mechanical properties, lifetime, and fabrication technology are areas offering potential for improvement.

Advanced resin-matrix composites currently exhibit deficiencies such as low interlaminar shear strength, low transverse tensile strength, poor impact resistance, and poor fracture toughness. Innovations are needed to realize the potential of woven broadgoods as an approach to enhance the properties of these materials. Performance improvements need to be demonstrated for typical graphite and Kevlar resin-matrix composites. At the same time, innovative failure mechanics analyses are needed to relate material performance to consistent properties for any composite material.

Temperature swings of 250K from minimum to maximum temperature will cause microcracking and changes in the strength and dimensional stability of composite structures used in space. Innovative proposals are sought for development of thermal control coatings for composite structures which would maintain temperature between 170K and 340K. Concepts for on-orbit repair or refurbishment of these coatings are also of interest.

04.03 Subtopic: Structural Metallics for Aerospace Applications

Centers: LaRC
LeRC

Future aerospace vehicles will require higher structural efficiencies than heretofore possible with currently available metallics over the entire range of aerospace applications, from light alloy systems to refractories. Improvements in structural efficiencies may be attainable through innovative structural concepts, processing methods and new alloy products with significantly improved properties. Areas of interest include, but are not limited to, the following examples:

- Alloy synthesis and development studies employing rapid solidification technology, powder metallurgy processing, and mechanical alloying have all resulted in laboratory quantities of materials with dramatically improved properties. Innovative exploitation of these advanced processing methods should produce new materials of nonequilibrium chemistries which will increase the upper use temperature for each principal alloy system (aluminum, titanium, superalloy) by at least 200F. Materials should be amenable to processing to foil gage thickness as well as conventional product forms of extrusion, forging, plate, or sheet.
- Advanced materials, such as intermetallic compounds of binary alloys, have unique characteristics and properties. Literature indicates that the platinum group materials have such compounds that could be capable of withstanding temperatures in the 1800-2000C range and be oxidation-resistant. These materials are usually difficult to produce and form in usable structures. The materials, if producible, would be useful for applications in various high-temperature rocket components such as liners, disks and blades. Needed are innovative methods to produce and characterize several of these compounds.

04.04 Subtopic: Intelligent Automated Structural Design Optimization

Center: LeRC

General purpose structural analysis methods based on finite element modeling have become the indispensable tool of structural designers in civil, mechanical and aerospace applications. These methods, as powerful as they are, provide only an analysis for the verification of a trial structure. Member sizes have to be determined by other methods before a finite element model can be defined as that of a final design.

Structural optimization theory has been developed to a sophisticated level both along nonlinear mathematical programming and optimality criteria approaches. Expert systems techniques that provide decisions one would expect from an expert in a particular activity are also approaching satisfactory levels of development. In some special cases analysis and optimization techniques have been integrated into a single automated optimum design capability. However, no general purpose capability exists that would start with approximate member sizes and then would develop a final detailed optimum design. Innovative approaches are needed to integrate the now well-developed three techniques of general purpose structural analysis, optimization and expert systems to create an "intelligent automated design optimization capability." For a given structural problem it could provide a suggested preliminary design concept, its modeling for analysis, a proper choice of design variables, objective function, active constraint selection and the appropriate optimality criteria, or nonlinear mathematical programming or heuristic optimization techniques. Such a capability could act as an expert designer within a broad class of structural design problems.

04.05 Subtopic: Space Structures Concepts And Materials

Centers: JSC
MSFC

Advanced materials such as graphite/epoxy and improved basic aluminum and titanium are being used in many commercial and military aircraft and have significant benefits in weight and cost savings for spacecraft applications. New concepts for applying these and other materials to a spacecraft such as the Space Station are desired, together with structural design criteria for new materials applications. Suggested areas of innovation would include, among others:

- Tubes and open sections fabricated from thermally stable composite materials connected with joints to form the basic structure.
- Joints and couplings with low or zero coefficient of thermal expansion for use on large space structures to achieve improvements in thermal stability.
- Module-to-module couplings to form large space systems.
- Expandable space-deployable structures for pressurized or unpressurized applications. Concepts might include inflatable envelopes with lightweight foam-in-place cores or shell components.

Concepts for design verification are required for the above.

04.06 Subtopic: Specialized Materials For Space Flight Applications
Center: GSFC

Innovative approaches are sought for the development of new materials and processing techniques aimed at ultimate use in advanced devices in research satellites and spacecraft instruments. Areas of current interest include but are not limited to the examples listed below. Other advanced concepts are also solicited.

- Development of peen-plated rapidly solidified (RS) metal powders and processes as protective coatings for structural materials.
- Transparent photo-elastic thin film materials which can be used for measuring and monitoring stress on structural member surfaces.
- An anaerobic compound which could be used for thread-locking applications and also meet spacecraft outgassing requirements.
- Inert films exhibiting low friction and long life at cryogenic (including liquid helium) temperatures.
- Aliphatic hydrocarbons collected as outgassing products in thermal vacuum tests of spacecraft and spacecraft systems cannot be sufficiently distinguished by present chemical separation and identification techniques. Improved chromatographic separation, improved spectral characterization, and matching techniques as needed.

04.07 Subtopic: Specialized Materials for Launch Site Facilities
Center: KSC

- Assembly Area Floor Covering

  Currently available floor coverings have failed to perform satisfactorily in areas where space hardware is assembled and processed. A new floor covering is needed that is resistant to hydrazine, nitrogen tetroxide, monomethyl-hydrazine, and other commonly used chemicals such as methyl ethylketone, sodium hydroxide, citric acid, isopropyl alcohol, nitric acid, Freon 113, and hydraulic fluids. Other requirements include cleanliness (non-particle generating), non-flammable, does not promote electrostatic discharge, low cost, ease of application and ease of repair. The flooring should be light in color and easy to maintain.

- Thermally Conductive Material that is Compatible with Hypergols

  An innovative approach to transferring heat through a dry well to a temperature transducer is sought (temperature range from 20F to 120F). Material must be compatible with the hypergolic fluid to be measured. It is preferred that the material be a fluid.

04.08 Subtopic: Welding Technology
Center: MSFC

Innovation in welding, controlling welds and improving properties of weldments are needed to achieve lower cost, lighter, more reliable components. Of particular interest are innovative techniques for:

- On-orbit repairs and joining.
- Modifying materials to improve weldability without degrading other desired properties of materials used in aerospace construction and fabrication.
- Mathematical models of temperature and stress in and around welds or relating weld structures to physical and mechanical properties, and models of entire weld processes to provide new, improved tools for weld and weld process development.
- Controlling the motions of robots and manipulators for materials processing functions, such as:

  —Programming of robots with multiple and redundant axes of motion in a simplified fashion to reduce programming time;

  —Measurement of the performance of robots, e.g., sensors to determine the accuracy of position of the robot as well as the velocity and acceleration during

  —Simulation of robotic processes, e.g., methods to off-line program robotic motion and incorporate the target process into the robot motion. This would include methods of graphic simulation and data base management relating to robotics processing of aerospace materials;

04.09 Subtopic: Thermal Protection Materials
Center: ARC

Future atmospheric entry vehicles will require more durable, minimum-weight, reusable thermal protection materials and systems. Among the new vehicles will be advanced space transportation vehicles, aerobraking, orbital transfer vehicles, planetary probes and military transatmospheric vechicles, such as aerospace plane. Innovative new concepts for new high density and low density rigid and flexible ceramic materials having extremely good thermal shock resistance and temperature capability to 1920K are sought. Among the possible materials are Si_2N_4, SiC, BN, Al_2O_3 and other refractory carbides and oxides. Possible forms are fiber/fiber composites, fiber/matrix composites, foams, and various woven structures. For example, fibers of suitable materials, woven into various forms, could be developed into thermal protection system components for flexible thermal barriers, gap fillers, and high temperature structural composites for application to the Shuttle Orbiter and future entry vehicles. To provide environmental durability, innovations are required for long-life waterproofing, both materials and techniques, to be applied to the current Shuttle Orbiter thermal protection system as well as to future composite thermal protection materials. New minimum weight load bearing and nonstructural thermal protection systems utilizing the above components and new processing methods to form them are of interest.

04.10 Subtopic: Structural Designs For Future NASA Space Missions

Center: JPL

Innovative approaches are required to ground-qualify large structural systems and to identify structural parameters on-orbit for future NASA missions. Innovative technology is sought in the following areas:

- Future NASA missions will use large flexible structural systems, such as antennas and large truss structures. Such systems cannot be qualified on the ground in their service configuration due to their size and the effect of the atmosphere and gravity. New approaches are required to assure program management that such systems will meet their functional requirements. Specific topics would include, but are not necessarily limited to, the following:
  - Tradeoff between subscale testing and subsystem testing;
  - Prediction of on-orbit dynamic characteristics using ground test data for linear and nonlinear systems;
  - Design of suspension systems for the qualification of large, very flexible structures.
- On-orbit identification of structural parameters will be required for future missions no matter how many analyses and ground tests are performed prior to the launch of large structural systems. The accuracy of predicting on-orbit dynamic characteristics is not expected to meet the requirements for effectively controlling such systems. This will become even more important for systems, such as Space Station, which will undergo periodic changes in configuration. Issues to be addressed in on-orbit system identification should include, but not be limited, to the following:
  - Optimum excitation methods;
  - Optimum location of sensors and actuators, that is, given only a limited number of sensor where should these be placed to maximize the information;
  - Identification of nonlinear systems;
  Tradeoff between acceleration, displacement, or strain sensors for system identification.

04.11 Subtopic: Reduced Weight Gondolas For Stratospheric Balloons

Center: JPL

A 10% reduction of payload weight for high altitude balloon flights will allow a 20% reduction in balloon volume, which will in turn increase the probability of success of a given flight by 40%. Innovative designs with new non-metallic materials should contribute substantially to such weight reductions under the following design specifications:

- A gondola with an enclosed volume of 350 to 400 cu. ft., with a bottom platform and one divider platform at midsection.
- The structure must rotate freely from its attach point to the balloon.
- The structure must support 3000 lbs; 2000 lbs of instrumentation plus 1000lbs. of ballast.
- The loaded structure must withstand up to a 10g pull on axis, and a 5g pull 45% off axis, from the attach point.
- The weight of the unloaded structure should be less than 250 lbs.

04.12 Subtopic: Lunar Materials Utilization

Center: JSC

Eventual manned activities in space will require or be enhanced by utilization of lunar materials as sources of mass, oxygen or other volatiles, nonmetals, and metals. Early work is needed to define the best processes to be carried out either on the lunar surface or in Earth orbit. Selection of appropriate equipment will consider reaction thermodynamics, reaction rates, engineering requirements, and system characteristics space testing. Specific areas for innovations are:

- Novel, efficient methods of extracting a range of useful gases, metals, and non-metals from lunar materials.
- Highly automated mechanical equipment, sized for the lunar or earth-orbital environments to extract and move lunar materials from their source to processing facilities.
- Simplified, self-contained systems that can process metallic elements into useful shapes, including bars, rods, wires, bricks and can be utilized either in the space environment or on the lunar surface.
- Numerical modeling systems for evaluating the interrelationship between various aspects of the lunar materials mining, extracting and processing subsystems to select best technical approaches or systems.
- Novel transportation systems for lunar materials.

TOPIC 05.00 TELEOPERATORS AND ROBOTICS

05.01 Subtopic: Telerobotic Technology

Centers: GSFC
JPL
LaRC

Systems combining teleoperation and robotic/autonomous features are envisioned for many future space applications, including unmanned science experiments, space manufacturing, structural assembly, module replacement, and servicing and repair. Innovations in all areas of telerobotic technology, basic system design, and implementation concepts are sought, including:

- Multiple manipulator/subsystems coordination and control: Overall telerobotics/robotics controls architecture, controls for reconfigurable designs, controls design and interfaces for integrated sensor systems.
- Manipulator dynamics and control: Modeling and control methods for manipulator flexibility and vehicle dynamics during attachment and stabilization; spatial planning, inverse kinematics, and control algorithms for manipulators with redundant degrees of freedom; adaptive/distributed control methods for flexible manipulators and deformable end-effectors; large structures (e.g., RMS) controls and stabilization during operations; passive and active damping and vibration control.
- Mechanical designs and actuators: High stiffness and strength-to-weight designs; high efficiency actuation methods; techniques for gentle capture, simple and secure latching, and sensing mating position.
- End effectors and integrated sensor systems: Reconfigurable designs with touch, force and torque, and proximity sensing; integrated sensor processing; tool and end effector interchangeability; tools/end- effectors/manipulators sensory continuity; collision avoidance sensors for real time use.
- Sensing and perception: Laser scanning and 3D imaging systems; image processing and analysis techniques for data base/world model definition and update; image enhancement and recognition; passive labeling and information markings; unlabeled object/fixture recognition algorithms; unambiguous determination of range, orientation, and motion of objects.
- Operator-machine interface: Multifunction displays and controls; visual and sensory data representation, methods for manual and voice interaction; supervisory, shared, and parallel control methods; interactive task planning and monitoring.

05.02 Subtopic: Artificial Intelligence for Space Station Applications

Centers: JSC
MSFC

Artificial intelligence will play a vital role in space operations in the Space Station era. Innovative approaches to the development of intelligent systems, both robotic and other knowledge-based intelligent systems, are desired. Of particular interest are innovative approaches based on the concept that intelligent systems attempt to achieve goals based on the interaction between modifiable subgoals, dynamic descriptions of the environment, and dynamic descriptions of the intelligent system itself. Research projects are solicited that demonstrate simply and minimally specified descriptions or models interacting with updating information; e.g., sensor information, in order to perform functions in the following for other Space Station related areas:

- Intelligent control of robotics for autonomous navigation and for carrying out assembly, maintenance, servicing, retrieval and other tasks. Demonstrations of intelligent robotic control software integrated with robotic hardware performing such tasks is highly desirable.
- Intelligent systems for process control functions, for automated fault diagnosis and repair functions, for data monitoring and reporting to the ground, and for planning crew schedules and activities.
- Hierarchical and distributed self-updating systems for Space Station subsystem management functions, and hierarchical control mechanisms for distributed networks.
- Also of interest are approaches to knowledge-based systems for engineering design and knowledge capture, tools to aid spacecraft crew and ground support personnel in updating intelligent systems software, innovative approaches to lower-level controlling software and hardware in support of intelligent systems, and approaches toward increasing the reliability of the Space Station through application of intelligent systems.
- Tools to aid crew and ground in updating expert system software for Space Station management functions.

05.03 Subtopic: Servo-Drive Mechanisms for Robotic Manipulators

Center: LeRC

Innovations are needed for high-response, low-loss, high-accuracy servo-actuator drives for robotic manipulators for Space Station applications other than the more conventional gear drives. Examples of such innovations are roller drives and hybrid systems comprising combinations of rollers and gears. Consideration should be given to high traction materials, coatings, and liquid lubricants (traction fluids). Drive systems should be capable of interfacing with artificial intelligence control systems. Drives should have virtually no backlash with extremely high stiffness and positioning capability.

05.04 Subtopic: Telescience
Center: JPL

Innovative instrumentation is required to allow scientists at various parts of the globe to interact and monitor progress in space-based experiments. The human operator must be supplied with all sensory cues and control capability necessary to simulate operator presence at the remote instrument site. A command-transmission link should allow the operator to close a control loop. Advances in the following technology elements are sought:

- Operator interface:
  —Fused displays: Graphical simulation for "look-ahead" planning fused with processed "images";
  —Automatic instrument command sequence generation: Generation of command sequence, on-line at display terminal/fused display;
  —Automatic multi-payload operation profile generation: Operational constraints factored into command sequence for payloads and carrier vehicle; constraints from multi-instrument science synthesis factored into command sequence.
- Onboard System:
  —Automatic on-line command sequence trimming: Factor spacecraft operational constraints into a multi-goal mission planner; a "target of opportunity" mission planner;
  —Resource management: Adapt power, thermal, control/pointing, data, etc. resources usage profiles to support changing mission sequences/constraints;
  —Fault diagnosis and recovery: Adapt command sequences to achieve goals in presence of error-best efforts basis; automatically diagnose and recover from faults;
  —Coordinated multi-payload pointing: Adapt pointing strategies to minimize/maintain disturbance envelope under multiple payload operational constraints.
- Ground System:
  —Multi-mission co-registration data base management: Allow for coordinated and co-registered "images" callable from remote terminals—international, multi-planet;
  —Automatic mission operations: Automatically arbitrate among possibly conflicting mission objectives, developed through distributed mission control functions;

05.05 Subtopic: Martian Surface Sample Acquisition, Processing, and Earth Return
Center: JPL

A planetary exploration mission to Mars raises the need for surface sample acquisition, sample processing, in situ analysis and Mars sample return to Earth. In order to insure that the scientific payload for Mars surface measurements and the Mars sample acquisition and processing equipment meet the needs of a Martian mission for surface exploration, innovative approaches are required to:

- Integrate the scientific payload for Mars surface measurements, and the sample acquisition and processing equipment. This can be done for in situ analysis and sample acquisition at a terrestrial location providing a good simulation of the Martian surface.
- Provide for in situ analysis of all major amounts of rock, soil and core samples to insure that the best sample choices are made for Earth return. Means for sample storage and preservation should be designed to insure that the integrity of each of the Martian samples is not compromised by environmental contamination in a spacecraft or exposure to harsh extremes of temperature and vacuum.

TOPIC 06.00 COMPUTER SCIENCES AND APPLICATIONS

06.01 Subtopic: Engineering Computer Science

Center: LaRC

Aerospace productivity promises to make significant gains through improved management of engineering data, advances in low-cost microprocessor hardware, and the use of artificial intelligence concepts. Needed innovations include:

- Procedures to interface engineering data management software to disciplinary and multidisciplinary engineering analysis methods and couple logic systems based on artificial intelligence to engineering data systems.
- Relational and other data structure approaches for engineering applications, to apply data management concepts to manage geometric and nongeometric data to integrate CAD/CAM tasks, and to enable the distribution of data management over networks of heterogeneous computers.
- "User-friendly" subsets of data base management systems that address scientific and engineering data and that are sufficiently modular to be usable across different computer and operating systems.
- High-level, engineering software tools such as algorithms for modeling three-dimensional objects realistically, and display techniques for visualizing functions of three variables. Improved interface systems for communicating information between humans and computers.
- Direct, iterative, or partitioning algorithms and methodologies in hardware and software applied to distributed engineering analysis, optimization and design computations over a large number of parallel processors operating asynchronously.
- New computing architectures using networks of processors offering the promise of order-of-magnitude improvement in computations in terms of increased speed and problem size.

06.02 Subtopic: Automated Software Development and Maintenance

Centers: GSFC
KSC
LaRC

Innovative approaches, including expert system concepts, are sought for the development, verification and maintenance of efficient and cost-effective automated software development and support systems. Automated support systems of particular interest to NASA include management control and tracking, requirements analyses and design specification, analysis and verification methods, development languages and support libraries, reusable software base development and systems integration techniques, code verification and testing techniques, and adapting and maintaining software for long-term missions and projects (10 to 20 years). Special support systems are needed for developing and testing time-critical applications, distributed system software, and fault-tolerant software. All such support systems must provide good documentation and visibility for the users. Potential applications extend across all NASA activities, including areas as diverse as Shuttle and cargoground processing, and flight system and subsystem simulation.

06.03 Subtopic: Knowledge Understanding, Representation, and Implementation

Centers: ARC
KSC

Knowledge understanding, representation, and implementation are the key elements to the effective development and implementation of expert systems for spaceborne, airborne, and earth-based applications. At the current time there exists a need for skilled knowledge engineers to translate the expert's knowledge to heuristics/rules for the applicable technical domain. Commercial "shells" are available which ease this translation but they are very domain-specific and are not efficient when interacting with unreliable data or with multiple technical domains. Development of knowledge engineering technology is needed in areas such as:

- Information extraction and understanding from multiple sensors with capability for automated interpretation of complex objects and data.
- Knowledge representation and implementation of multiple knowledge sources.
- Global knowledge understanding, representation, and control of multiple, domain-independent knowledge bases.
- Integrated data bases for distributed knowledge-based systems.
- Machine learning with automated capability for the generation of new heuristics.
- Automated programming development, verification, and validation.
- Hierarchical control mechanisms for distributed knowledge-based systems.
- Task planning and reasoning knowledge-based systems capable of operating in dynamic domains with rich representation capabilities to enable reasoning about concurrency and subsystem interaction.

- Man-machine interfaces capable of displaying integrated dynamic system relationships that are understandable and accessible to the human at a higher level of communication; i.e., allows the operator to input into the computer in a flexible and natural manner what is desired and the reason for the request.

06.04 Subtopic: Knowledge-Base Technology for Software Components
Center: JPL

The componentization and reuse of software provides the potential of significant increases in productivity and reliability in the development of software systems. Several key technology hurdles must be overcome in order to enable the advancement of this technology for software development. One of these hurdles is the assessment of software components for reuse. Another is the classification and retrieval of software components. Innovative approaches for software component assessment, including methods, metrics, and tools to enhance component reuse; and innovative approaches and tools that will provide new classification systems and reuse-oriented retrieval systems are solicited.

- An assessment process needs to be automated to include evaluation of various types of components, not just source code components. Similar to hardware, quality factors of a component must include behavioral, environmental, and historical characteristics in addition to standard complexity measures. The appropriate factors for each type of software component must be identified and metrics to measure these factors developed. An assessment process assisted by automated tools and categorization techniques must be developed.
- Software components include not only source code but other products produced in the software development process which have the potential for reuse. Current classification schemes are very restrictive and usually limited to the application domain of the classifier. Additionally, the search methods for retrieval of components is also limiting and not strongly interconnected with the software design and/or specification processes to allow the development of systems out of existing components. The advent of knowledge-based systems presents the potential for more successful approaches to component classification and retreival.

06.05 Subtopic: Software Systems for Mission Planning and Flight Control
Center: JSC

State-of-the-art enhancements such as artificial intelligence (AI) and graphics are needed to improve the techniques for pre-flight and real-time mission planning and control in support of flight operations of the Space Shuttle and the Space Station. Examples of areas of high interest for mission planning and control include:

- Automated knowledge acquisition expert systems.
- Intelligent computer-aided training systems.
- Artificial neural systems.
- Intelligent CAE systems.
- Concurrent AI on parallel processors.
- Real-time distributed data base systems for parallel processors.
- Auto decomposition of programs on parallel processors.
- Establishment of benchmarks for parallel processors.
- Robotics software development.
- Machine vision software development.
- Integration of different AI systems (vision, speech, expert systems, . . .).
- Fuzzy logic.
- Porting AI software to ADA.
- Phoneme based speech recognition systems.
- Speech recognition system based on audio cortex windowing mechanisms.
- Massive parallel processing speech recognition systems.
- Semantic knowledge-based voice recognition systems.
- Low bit rate speech output systems.
- High fidelity single frame graphics systems.

06.06 Subtopic: Integrated CAD/CAE and Knowledge-Based Systems
Centers: JPL
KSC

A significant opportunity exists for innovative means to integrate CAD/CAE and knowledge-based systems in the design, development, testing and operation of spacecraft and missions dedicated to the exploration of space. The use of CAD/CAE systems in the design and development of space flight and payload systems provides a knowledge base built for the mission-specific application. Application of artificial intelligence for the support of mission operations involves the construction of a large knowledge base. There would be tremendous benefit if the knowledge base created with CAD/CAE tools during design and development of a mission could be carried through integration and test and form the knowledge base for the support of the mission operations. Two major benefits of such an integrated system would be: first, in developing an error-free knowledge base system for the conduct of operations, the overhead would be eliminated since it would be naturally constructed during the design and development; and second, a means would be provided for the transference of the engineering knowledge of the system developers and implementors to the staff which must operate the mission.

06.07 Subtopic: Computer Sciences Advances in Support of Computational Physics
Center: ARC

Computational physics clearly has become a powerful and cost-effective tool for solving a large class of aerospace problems. Innovative computer science concepts are needed to move the state of the art in computational resources forward and to hasten the availability of more powerful computational resources for computational physics. Innovation is sought in computing speed, mass storage, longhaul communications, and computer graphics. Some examples are:

- Approaches and methods for applying parallel processing to computational physics and for predicting the performance of the system prior to its construction. Architectures of interest include multiple instruction- stream multiple data-stream (MIMD), systolic arrays, data flow, demand driven and reduction machines. In addition to hardware architectures and performance prediction techniques, innovation in the supporting systems software (operating systems, programming languages, debuggers, etc.) is sought.
- Approaches in computer graphics for the visualization of complex three-dimensional fluid flow phenomena derived from computation or experiment. Specific techniques of interest include techniques for enhanced display of internal flow structures, enhanced depth perception, quantitative comparison of numerical and experimental fluid flow data, and high-speed cost-effective image processing techniques suitable for analysis and synthesis of fluid dynamics data.
- Advanced data storage and data compression techniques.

TOPIC 07.00 INFORMATION SYSTEMS AND DATA HANDLING

07.01 Subtopic: Focal-Plane Image Processing
Center: LaRC

The end-to-end performance of image gathering and processing for (near) real-time teleoperations and robotics is severely constrained by the requirement for a serial stream of image data from the (2-D or 3-D) image-gathering system to the image-processing computer. Innovations in focal-plane image-processing techniques are required to overcome this constraint. These innovations may typically be concerned with coding for image compression, detecting edges and segmenting images, analyzing features in the image for patterns of interest, detecting and tracking moving objects, and restoring or enhancing images. The techniques may typically include integrated sensor-array sensing and processing, multi-resolution parallel processing, Gabor elementary signal coding, correlation and feature extraction, shift- and distortion-invariant recognition, and optical and acousto-optic processing.

07.02 Subtopic: Spacecraft Operations and Data Management
Center: GSFC

Spacecraft operations, control and scheduling are conducted through a complex interaction of project scientists, network support managers, and network control managers, using mission planning terminals, payload operation control centers, network operation control centers and other facilities. This requires the assimilation and processing of massive amounts of data. The end result is the generation and transmission of suitable commands from the control center to the spacecraft and reception and processing of the telemetry and scientific data sent by the spacecraft. New and innovative concepts are needed to improve and upgrade systems and procedures so that they are fully able to meet the demands of the coming decade. The future environment will include the independent control and operation of some experimental payloads by experimenters from their home institutions; the use of expert systems to automate monitoring, control, scheduling, and fault isolation functions; and distributed scheduling of communication links and processing systems. This will require innovations in the following areas:

- Scheduling algorithms that are efficient for distributed, individually controlled resources.
- Development tools to aid in the implementation of expert system knowledge bases for control centers.
- Design of distributed expert systems for performing control, monitoring, and fault isolation for spacecraft and payload components, and supervisory expert systems for monitoring and advising operators based on these subsystem expert system inputs.
- Control center designs with optimal allocation of

planning, scheduling, and monitoring functions between operator and machine.

- Data system designs that allow selective processing and display of limited payload data subsets in near real time for control purposes by sampling network communications.

07.03 Subtopic: Signal and Information Processing

Center: GSFC

Innovations are needed in methods that increase the usefulness of raw data from spaceborne sensors in answering specific questions of current concern. Examples of areas of interest are: real-time data compression, processing and storage so as to reduce telemetry costs and labor intensive processing costs; graphic and display techniques that summarize large volumes of data in readily comprehensible form; and automated techniques to infer secondary parameters from raw data. Techniques with general applicability to data from a class of sensors (as opposed to one specific sensor) will be higher priority. Sensors producing large volumes of data such as MODIS, HIRIS and SAR, to be deployed during the space station era are of particular interest.

Linear array detectors are to be used in an instrument to provide both scientific data as well as real time and post facto information on the pointing direction of a spacecraft. Although the scientific data can be processed at a low rate, the requirement on pointing knowledge is such that edge determinations must be made in real time. In one case, the target will be the sun with solar pointing as the objective. An image of an edge of the sun is focused somewhere on the linear array and data are shifted out from the linear array at a rate of about one frame per 10 msec. The requirement is for a complementary combination of hardware design and software approach that can survey an image made up of >1700 pixels, identify the general area of the edge of the solar image, perform appropriate calibrations for pixel response to the selected pixels, and then derive an edge position to high accuracy.

07.04 Subtopic: Management Information Communications

Center: GSFC

A goal of NASA is to improve the productivity of all its employees. Improving productivity in management of technical projects and programs is possible through the use of timely, readily accessible, and efficient means for communicating and controlling status, requirements for action, and changes. An immediate, accurate flow of information among all concerned with management is essential for making major enhancements in decision-making, project and program control, and intra-agency communications. Therefore, innovations are sought using advanced communications and data management technologies to provide vastly more effective means than now available to enhance productivity in program and project management. One example of this would be innovative techniques in the development of an effective measure of procurement productivity in an R&D environment.

A variety of computer connections and local area networks are being formed with an increasing need for resource connectivity. Furthermore, fiber optic technology will be used to help satisfy the demand for higher data transfer rates. Accordingly, new interface, software and hardware technology needs to be developed to allow common use of fiber LANS by hosts with different protocols. In addition, the proliferation of new host interfaces requires careful monitoring and adjustments since the technology is changing rapidly. Innovative uses of microcomputer technology are sought to develop routers and gateways to provide connectivity, addressing, protocol conversion and network management functions.

07.05 Subtopic: Ground-Based Data Management Systems

Center: GSFC

One of the key issues that must be addressed and resolved to support the next generation of space research and operations (e.g., Space Station and EOS) is managing, understanding, and effectively utilizing the vast amount of scientific data. Presently, ground-based data management systems perform primitive data ingesting by storing all data onto magnetic tapes and archiving the tapes in a system that can identify a particular tape based on some simple feature descriptors such as sensor type, data, time, and location. However, such a procedure is very time consuming, cumbersome, and self-limiting in that only preconceived data are known about and selected; and other scientific disciplines are presented from using potentially valuable data due to the lack of a proper data base and catalog.

Consequently, new and imaginative approaches must be adopted that will allow the automatic ingesting of scientific data in an intelligent manner so that the data or some abstracted view of the data can be characterized in the broad context of a multidisciplinary environment and made available interactively to the full scientific community.

In support of these approaches, advanced data systems must be developed using new and emerging computer technologies that will intelligently perform the ingest operation. The development of such a system appears now possible utilizing third generation expert system tools combined with advanced data structures, spatial, and graphical database designs and pattern and image processing. This will require development in the following areas:

- Logical data structures using expert and spatial database systems that maintain data context and are interconnected.
- Intelligent processes for determining data context in a data world domain.
- Intelligent processes that will allow the identification of object features in the ingested data.
- Graphical processes that can summarize the representation of data object information within the spatial data.

07.06 Subtopic: Heterogeneous Distributed Data Base Management

Center: GSFC

One of the most serious problems affecting the Agency, both in the scientific and administrative realms, is that caused by the tremendous diversity of data bases and data base management systems. In order to access data from sources other than their own, users are forced to learn a plethora of different languages and access methods.

Research is needed for developing tools for uniformly accessing heterogeneous distributed data bases. Suggested areas for innovation are:

- Data set editors for data browsing and updating.
- Report generation capabilities.
- Host programming language-based data base access.
- View update capabilities.
- Automated query formulation aids.

07.07 Subtopic: Software/Work Station Development for Remotely Sensed Data

Center: JPL

Innovations are required to advance the performance of data systems and the workstation environment for remotely sensed data. Specifically innovations are sought in the following areas:

- The data volumes to be produced by the high rate instruments currently planned for the Earth Observing System (EOS) have the potential to easily overwhelm the scientific community. Not only will these instruments produce high spatial resolution imagery with a large number of spectral channels, but data will be acquired for up to a 15-year period with some regions being covered as often as every two days. In order to effectively and efficiently analyze these large volumes of data, innovative new approaches must be implemented. The initial image analysis tool must provide the user with the ability to survey these large volumes of data to select periods of time, places on the earth or regions of the electromagnetic spectrum that are changing. Those regions will then be the focus of further research. Specifically, a software tool which can be used on a relatively small image processing computer should be developed to analyze the high rate instrument data. This tool should include the following functions which could be accomplished in a "joystick" fashion at a rate commensurate with the rates of the EOS instruments (SAR and HIRIS, specifically):
  —Automatic image co-registration between all dimensions (spatial band, polarization, incidence angle and time);
  —Automatic image scan through any dimension;
  —Display of "detected change" data in 2-dimensional format;
  —Display of reflectance as a function of any dimension for selected pixels within the image;
  —3-Dimensional image rotation to any selected perspective view with the ability to continue the above function.
- The scientific analysis and applied uses of spatially organized remotely sensed data are often dependent on the ability to co-register data sets which have been obtained from various sources. Though processes by which spatially disparate data sets can be merged are well known, it remains an extremely costly, time-consuming and error-prone task. The difficulties seem to arise in making the necessary human operator an efficient part of the solution. Innovative approaches to spatial data registration are needed which rely on creative uses of hardware, data management and knowledge-based software, and human-computer interfaces in a workstation environment. Such a workstation would employ whatever techniques are available and cost-effective to enhance the productivity of the operator and decrease the amount of time and effort necessary to co-register geographically distributed environmental data as a precursor to accomplishing multi-sensor data fusion.

07.08 Subtopic: Image Analysis Techniques

Center: GSFC

As the spectral and spatial resolution of spacecraft sensors increases, so does the volume of data available for analysis. There is increasing emphasis on enhancing scientists' productivity by presenting the data in image form to facilitate the quick detection of patterns in the information (something the human eye and mind can do better than any current machine). Advances in image processing and display hardware and parallel computing architecture (such as GSFC's Massively Parallel Processor—MPP) have led to a point where there is a substantial potential for significant breakthroughs in techniques for analyzing image data. Improvements in image analysis technology will result in greater automation and convenience in the analysis of the massive volumes of data that are to come and will significantly increase the productivity of the scientists using the data. Suggested areas for innovation are:

- Development of low-cost, remote, image display techniques including microcomputer display devices and image coding techniques to support the rapid transmission of image data to remote locations.
- Integration of image and graphic data structures to provide rapid identification and access to images with particular features in a multi-image data base and to permit the selection of subsets of images selected on the basis of information content.
- Development of pattern recognition techniques for use with multispectral data which emphasize the use of both the spatial and spectral characteristics of the data.
- Development of techniques for effectively assessing and analyzing data sets derived from sensors with non-congruent resolution and/or varying time of observation.
- Development of new techniques for generic data representation through computer graphics to study such data streams.
- Development of expert systems to perform image analysis and information extraction.
- Development of graphics-oriented applications executive for current and future NASA data and information systems.

07.09 Subtopic: Search for Extraterrestrial Intelligence (SETI)

Center: ARC

The Search for Extraterrestrial Intelligence (SETI) Program is conducting R&D in preparation for a microwave observing project, which will use the largest existing antennas with unique radio frequency spectrometer and signal analysis equipment. Proposals should demonstrate knowledge of SETI, and present innovative ideas relevant to SETI, which have potential for commercial application.

Areas needing innovation beyond the state of the art include:

- Design of wideband (0.5 GHz) high resolution (1 Hz) radio frequency spectrometer.
- Development of efficient signal analysis algorithms for the detection of a constant or slowly drifting signal in the spectrometer output.
- Development of efficient signal analysis algorithms for the detection of a low duty cycle pulse signal.
- Design of high speed hardware to implement signal analysis algorithms.
- Design of a system to discriminate radio frequency interference (RFI) of terrestrial origin and known radio astronomy sources from signals of possible ETI origin.
- Development of a knowledge-based expert system to schedule and control SETI observations, to integrate the results of signal analysis and RFI tests, and to archive results of interest.

TOPIC 08.00 INSTRUMENTATION AND SENSORS

08.01 Subtopic: Planetary, Earth Sensing and Astrophysics Instrumentation

Center: JPL

Innovations are required to advance the performance of instruments for planetary exploration, remote earth sensing and astrophysics applications. Innovative technological advancements are needed across the electromagnetic spectrum:

- Charge-coupled devices: Improvements or alternatives to traditional overlapping gate structures utilizing state-of-the-art submicron fabrication techniques; reduced readout noise through the development of lower noise on-chip amplifiers; fabrications on monolithic non-silicon materials; dark current reduction techniques or structures.
- Infrared detector arrays: Innovative concepts for detector materials suitable for operation in the 2.5 to 30 micron wavelength region; advancements in multiplexer architecture, interconnect technology, and monolithic structures. Requirements include extremely low noise, high uniformity, very low dark current, and high radiometric fidelity.
- Ultraviolet filter technology: Innovative concepts for filters to be used for far and extreme ultraviolet imagers and spectroscopy. Requirements include high rejection of visible and infrared radiation, low scattered radiation and the potential to be space qualified. Improved filters for the vacuum-UV and middle-UV regions are sought. These are of two classes:

  —Alkali metal filters for the 120 to 180 nm region. In-band transmission should exceed 0.4; transmission at wavelengths greater than 400 nm should be less than 10^{-8}

  —Thin-film interference filters with transmission bands 20 to 30 nm wide within the 200 to 350 nm region. In-band transmission should exceed 0.2 and out-of-band transmission should be less than 10^{-6}. Wavefront distortion should not exceed 1/4 wave.

- Particle collection techniques: New concepts and techniques for collection of solid micron and submicron particles in planetary atmosphere (including the earth) and vacuum of space are needed to permit determination of particle size distributions, compositions, height profiles and particle morphologies with a minimum of sample handling. It would be desirable to collect particles and be able to perform scanning electron microscope imaging, electron beam induced X-ray analysis and X-ray fluorescence analysis without extensive sample preparation and without introducing heavy element interferences.

08.02 Subtopic: Earth Sensing from Space

Center: GSFC

Satellite and supporting in-situ observations of precipitation rates, cloud cover parameters, and broadband radiation parameters at the surface and top of the atmosphere are needed to satisfy global-scale climate monitoring requirements. Innovations are especially desired in the following areas:

- Active (radar) and passive microwave techniques for measuring precipitation including interpretation techniques (algorithm development), error analysis and sampling requirements to obtain monthly, 500 × 500 km spatially averaged rainfall statistics.
- Improved techniques (direct and indirect) for measuring rainfall at the surface, both over land and oceans, including techniques to develop meaningful space and time averages of area rainfall that can be used to verify and/or calibrate space-based measurements of rainfall.
- Improved and/or new approaches to measuring macrophysical parameters such as particle size, phase, density, albedo, and extinction coefficient, based upon active and/or passive radiometry.
- Improvements in the sensitivity and time response of cavity-type radiometers for absolute measurement of radiant energy (reflected and/or emitted) with an angular resolution of $<.02$ str, a precision of <1 w/m^2/str, and a time constant of <3 seconds.
- Polarization sensor for earth observation: An imaging sensor that can be used to make polarization measurements of a scene is desired by NASA. Polarization imaging is desired for research purposes in remote sensing applications such as agriculture, forestry, hydrology, atmospheric studies, oceanography and water quality. System concepts are sought for a polarization image sensor that will operate in the 0.4 to 1.0 micron range and would be capable of determining the Stokes parameters of a target from low earth orbit altitudes. The sensor will be used to determine both polarization and radiometric properties of ground features as well as the atmosphere. Consequently, registered data at high radiometric accuracy are also important attributes for this sensor. To keep the sensor relatively simple, instantaneous fields of view in the several hundred meter range should be considered.
- Space-based laser altimeters: Measurements of ice sheet topography, terrain profiles, and cloud-top heights with laser altimeters operating near 1 micron wavelength are planned for a number of future spacecraft. Technological innovations in the laser transmitters and optical receivers are required to ensure high signal-to-noise for each laser pulse measurement of range between the Earth's surface and the spacecraft. Space- based laser altimetry poses unique technological challenges. These include:
  —Development of short pulse (1 nsec) transmitters using cavity-dumping or other technology in solid-state lasers;
  —Noise reduction in silicon avalanche photodiode receivers;
  —Development of a Geiger-mode avalanche photodiode detector for ultra-low noise operation with thermoelectric cooling to 200K temperature;
  —Integration of detector pre-amplifier, pulse discriminator, range-gate, and time-interval electronics into a miniaturized, low-power, altimeter processor;
  —Implementation of waveform digitization electronics to analyze pulse-spreading effects caused by the altimeter range.

08.03 Subtopic: High Resolution Remote Sensing for Earth Observations

Center: ARC

Applications involving Earth observations of dynamic phenomena require a flexible and responsive remote sensing system. Specific system features include high spatial resolution of the data and a capability for directly receiving data. These features are necessary for measuring, monitoring and evaluating Earth features that exhibit measurable change on the order of one to four days. Exiting remote sensing instruments cannot provide the high resolution and timeliness required to serve commercial applications.

Innovations are desired which produce a multispectral sensor with the capability to vary in waveband range, demonstrate spatial resolution of 2.5, 5, and/or 10m instantaneous field of view (IFOV), and have the ability for users to display and evaluate the data in real time. Proposals emphasizing commercial applications, incorporating into the system structure real-time capabilities and adaptability to space flight are of particular interest.

08.04 Subtopic: Global Biology Sensors
Center: ARC

NASA's interdisciplinary activities in global biology and global habitability focus on an understanding of global bio-geochemical cycles. Proposed innovations should address accurate, precise, and sensitive (ppb level) measurements of compounds containing H, C, N, O, P, and S of atmospheric aerosols. Fast response detectors are required for measuring biogenic gas fluxes (methane, nitrous oxide, carbon dioxide, etc.). Measurements will be made in field stations, remote field stations, and by aircraft sampling of the atmosphere, and instruments must measure a large variety of compounds on an hourly basis (over a 24-hour period). Innovations are needed to provide rapid, high-resolution spectrometry for determining the biochemical content of intact plant canopies (protein, phosphorus, nitrogen, lignin, starch, cellulose, etc.). The instrument should have a fast response time (less than or equal to 1 sec/spectrum), high spectral resolution (0.5), cover the visible to shortwave infrared region (400-2500 nm), and be able to support derivative spectral analysis. An optimum design would produce image data (line rather than point observations) and be capable of operation from an airborne platform, as well as in the field and laboratory. Innovations are required for instruments to monitor wildland fires on local, regional and global scales, including inventories of fire events and measurements of their thermal characteristics. Measurements are required in the field as well as from aircraft and/or spacecraft platforms. A tracking and staring capability will be required for actual management and control of wildland fires from aircraft/spacecraft platforms. Improved computer techniques are needed to model gas and particle atmospheric interactions and conversions.

08.05 Subtopic: Oceanographic Instruments and Software
Center: JPL

NASA carries out various research programs on physical and biological oceanography. Innovations are sought in the area of sensors, in the transmission of acquired data and in software for analysis of satellite images. Topics of particular interest include:

- Instrumentation for measurement of the directional properties of short surface waves (1 to 30 cm) in the deep ocean. Either the wave amplitude or slope are to be sensed, together with the ambient properties of the swell, the wind speed and direction, and the sea and air temperatures. Moored or ship-based operation is acceptable.
- A moored surface buoy system for the measurement of vector-averaged currents, temperature, and salinity in the region extending downward to 15 m depth. The system should provide for data transmission to a satellite, and should incorporate internal data storage for up to 12 months duration in case of communications failure.
- Instrumentation for in situ measurements of light scattering in the ocean including the angular distribution of scattering over the wavelength range important to photosynthesis.
- Algorithms and software for the analysis of GOES VISSR images and for interpretation of the daily and short-term mean incident solar irradiance over kilometer-scale areas at the sea surface. Software must be compatible with Digital Equipment Corporation's VMS operating system and with standard image display hardware.

08.06 Subtopic: Instruments for Geological Research
Center: JPL

The NASA Geology Program utilizes aerial mapping to determine surface composition and topography, and carries out field surveys as an integral part of the work. Innovation and development are sought for the following instruments:

- Multispectral thermal camera: A field portable thermal imaging instrument would enable study of the compositional and textural heterogeneity of the undisturbed surface. Current thermal imaging instruments lump the 8 to 13 micrometer thermal region into a single channel. Needed is a rugged, lightweight, field portable instrument with 0.5 micrometer resolution over this band. The instrument should divide the 15 to 50 degree field-of-view into 200 × 200 pixels, with a signal-to-noise ratio of 100 to 1 for a 30C black body. It should incorporate digital recording and be capable of displaying simple images, differences, and ratios in the field.
- Scanning imaging altimeter: Improvements over current stereo-photogrammetry are sought for geomorphology studies of kilometer-size areas. Data acquisition, storage, and display are of principal concern. Either radar-based or laser-based altimeters carried by aircraft are envisioned, but other systems are not excluded. Requirements are:
  – Continuous swath or contiguous frame capability, with a swath width 1 km or greater;
  – Vertical and horizontal resolution each less than approximately 1 m;

—Near real-time 3-D display for preliminary analysis, with digital storage for final analysis.

08.07 Subtopic: Spectroradiometric Standards for Ultraviolet Remote Sensing

Center: GSFC

Remote sensing of the Earth's atmosphere in the ultraviolet is becoming crucial to our understanding of the atmospheric environment and detection of anomalous signatures in the atmosphere. Presently atmospheric ozone is being monitored over the long term using ultraviolet remote sensing techniques from the ground and space. These measurements are sensitive to atmospheric contamination from aerosols from cosmic and volcanic sources. One measurement limitation results from our inability to maintain calibration of the instruments to high enough accuracy to detect long-term changes in our environment that are small but vital. Precision of the measurements are 1 percent or better, however, radiometric standards are known to accuracies of only 2-5 percent in the wavelength range of 300 to 160 nm and are not good enough to detect long-term trends in our environment. To date, radiometric standards in the ultraviolet have been maintained by the National Bureau of Standards; however, fundamental improvements in accuracy have not been accomplished in nearly a decade.

Innovative research and developments are needed for absolute spectroradiometric standards in the ultraviolet. Improved irradiance, radiance, and reflectance standards in the ultraviolet are needed. These should be combined with stable and sensitive detectors operating in the near to vacuum ultraviolet (300-160 nm) as basis for calibrating remote sensors operating over this wavelength range. Radiance and irradiance standards should be capable of operating over a wide dynamic range (4 orders of magnitude). Goniometric (angle) response should be characterizable to the order of 1 percent. Results of this research will have applications to ground monitoring systems, satellites and instruments planned for Shuttle and Space Station.

08.08 Subtopic: Tunable Solid State Lasers, Detectors and Lidar Subsystems

Center: LaRC

Measurements to improve understanding of atmospheric chemistry and dynamics from a polar orbiting platform require development of new solid state laser materials, laser transmitters, detectors and lidar subsystems to meet requirements of energy/pulse, efficiency, lifetime and reliability. Tunable solid state laser technology covering the wavelength spectrum from near UV to the near IR is required to conduct scientific experiments to measure atmospheric aerosols (multiwavelength), molecular species, meteorological parameters (H^{20}, pressure, temperature, winds). Semiconductor laser arrays as optical pumping sources for solid state lasers hold the potential to increase wall plug efficiency substantially over conventional flashlamp technology. Innovative developments in device and component technology in detectors, laser materials, laser transmitters and Lidar subsystems are required for Lidar applications from polar orbiting platform in the following areas:

- Tunable laser materials from .180 micrometer to 11.0 micrometer.
- Semiconductor arrays to optically pump solid state host materials.
- Improved techniques to optically pump laser materials with semiconductor laser arrays.
- Lightweight mirrors in the one meter range.
- Single element detectors and TDI detector arrays with increased sensitivity at thermoelectric cooler temperatures.
- Heteroepitaxy devices for low-noise and high-speed applications.
- Hybrid or monolithic detector/preamplifier structures to reduce electronic noise.

08.09 Subtopic: Sensors for Atmospheric Aerosols

Center: LaRC

Innovations are desired in sensor techniques, sensors and sensor systems to permit ground-based, airborne and/or spaceborne monitoring of atmospheric aerosols produced naturally or from man's activities, including determination of:

- Vertical concentration profile.
- Size distribution from submicrometer to micrometer-sized particles.
- Particle composition and morphology.
- Aerosol optical properties.
- Aerosol spatial distribution and fluxes.
- Ancillary atmospheric data required for analysis of aerosol properties.

08.10 Subtopic: Atmospheric Measurements and Analyses in Manned Space Missions

Center: MSFC

Innovative concepts are sought for measuring systems to determine the composition and levels of contaminants in confined environments such as Space Station or long duration manned missions including planetary exploration, and to determine atmospheric composition and possible toxic constituents. Included are sensitive analysis and detection methods, and automated systems for integrating the various sensors required for analysis of a complex atmosphere and to compress data and present it in a usable form.

08.11 Subtopic: Behavior and Effects of Contamination in Space
Center: GSFC

As the design of modern spacecraft becomes increasingly more complex, and as spacecraft performance goals are extended to new boundaries, the importance of understanding contamination degradation becomes substantial. It is necessary to describe the basic behavior of molecular and particulate contaminants, to quantify amounts of contaminants transferred between sources and receivers, and finally to establish the effect of the contamination. Innovative flight experiments and corresponding analytical models are sought to further define molecular and particulate contamination behavior and effects on launch vehicles and orbiting spacecraft including:

- Flight instruments capable of quantifying molecular contamination environments including: local gas pressures; mass spectrometry; other devices for contaminant identification; effects of UV on outgassing and re- emission rates of contaminants.
- Flight instruments capable of quantifying particulate contamination environments including: launch particle redistribution; on-orbit particle clouds; on-orbit particle source events (EVAs, venting, water dumps); effects of particle obscuration on optics and solar arrays.
- Verified analytical models to describe and predict the above defined contamination environments.

08.12 Subtopic: Infrared Technology for Astronomical Applications
Center: ARC

Innovative concepts and techniques are needed to support spaceborne infrared (IR) astronomical telescope projects:

- To achieve ultimate performance in low-background instruments, improvements in the sensitivity of discrete IR detectors and integrated IR detector array electronics, operating at cryogenic temperatures are required. Means to extend the spectral coverage beyond 200 micrometers, and means to reduce device dark current and susceptibility to particle radiation are also required.
- Methods to count individual IR photron events, either directly or via upconversion, are desired.
- Novel techniques in long-wavelength (>20 micrometer) IR filter design and manufacturing are required.
- Novel coolers and their components are required. Examples are continuous cooling between 2 and 20K and between 1 and 2K; nonhydrated refrigerants, magnetic shielding, and low-current/quench-protected magnets for 1K magnetic refrigerators; and pulse tube refrigeration techniques.
- High-quality, low-cost fabrication techniques are needed for optics capable of diffraction-limited performance down to 1 micrometer. Included are both small optics for instrument applications, and large (>1 meter) lightweight panels for use in segmented mirrors.
- Novel techniques are needed for in situ evaluation of image quality in cooled IR telescopes. This includes development of sensing instrumentation and algorithms for correction of focus.

08.13 Subtopic: Exobiological Analysis of Cosmic Dust
Center: ARC

Analysis of comet dust particles, which are presently collected via the NASA- AMES U-2 high altitude collection program, is required for preliminary characterization and interpretation of organic matter formed in the early solar system and interstellar medium. Design of innovative analytical instrumentation and procedures are required for future use in planned dust collection and analysis of space station and comet sampling missions.

Innovations are desired in the following areas:

- Development of non-destructive analytical techniques that will characterize the carbonaceous component of comet dust particles in terms of biogenic element contents (H,C,N,O,P,S).
- Development of non-contaminating sample preparation techniques to include nonorganic mounting medium and microtomy procedures.
- Modification of state-of-the-art secondary ion mass spectroscopy for the study of lateral distribution of trace elements and isotopic ratios in cross-sections of dust particles.
- Detection and identification of organic compounds (e.g., amino acids, carboxylic acids, aliphatic and aromatic hydrocarbons, nitriles, nitrogen heterocycles) at the 10^{-18} to 10^{-16} mole level.

08.14 Subtopic: Spacecraft Instruments
Center: JPL

Innovations are sought in the development of spacecraft instrumentation. Specific areas of interest include the following:

- Observation of solar oscillations can be achieved with magneto-optical filters. These filters require magnetic fields of approximately 6000 Gauss over an air gap volume of 2.5 cm diameter by 5 cm length. An innovative compact magnet system is sought which will provide field uniformity to within 3% throughout the gap for five years. Shielding against field leakage must be included in the design because of spacecraft constraints. Components within the gap are to operate at 200C.

- Outgassing of spacecraft hardware causes degradation of optical and precision surfaces. JPL has devised and evaluated in the laboratory a method for trace gas analysis for the local spacecraft environment which could serve as a versatile and accurate monitor, and which may have wider applicability than that indicated here. It employs a quadruple mass spectrometer and an ion source of special design to generate both positive and negative ions. Innovation is needed in the fabrication of the ion source and interfacing of a source to a commercially available quadruple mass spectrometer. Also needed is development of a space qualified electronics package for the data acquisition and analysis.

08.15 Subtopic: Instrument Power Distribution and Control

Center: GSFC

Scientific instruments for space application require power distribution and control with unique requirements such as low noise, low and high voltage, precise regulation, high efficiency and high specific power density, all at high reliability with low cost. The primary input power interface has been 28vdc, and the output power interface is unique to the specific instrument requirement. Future power systems will utilize 20khz ac power distribution, and in order to minimize overall system losses, the input power interface for future instrument systems will be 20khz ac rather than the conventional 28vdc. The transition from 28vdc to 20khz ac will be gradual, but nevertheless there is a need to gain experience with the 20khz interface for future instrument systems. This new interface will lead to new approaches in instrument power distribution, with potential performance improvements. An intermediate step may be the use of 20khz for power distribution within an instrument and yet still have a 28vdc power interface which can be used on near-term applications. Such a system would utilize a 20khz inverter for the generation of the ac voltage for power distribution which eventually would not be required when the 20khz ac power interface is established. There is a need to explore and develop innovative means for achieving highly efficient power distribution and control of instrument power with greatly reduced system noise utilizing the 20khz technology and yet realize a low-cost system.

Specific innovations are sought to improve inventor efficiency and reduce system noise under varying load conditions.

08.16 Subtopic: Detectors and Detector Arrays

Center: GSFC

Detectors and detector arrays for space astronomy, astrophysics, geophysics, and atmospheric studies at varying wavelengths require innovations. Among the areas needing innovations beyond the present state of the art are:

- Low-noise photocathodes.
- Large arrays of microchannel plates.
- Multiple-bundle, fiber-optic light pipes.
- X-ray detector arrays (8×8 and larger).
- Cryogenic infrared array detectors.
- Remotely deployed magnetic field seismic instruments for geophysical monitoring and surveying.
- Large area (greater than 40 cm^2) two-dimensional position-sensitive (about 1 mm) solid-state nuclear particle detectors.
- Laser-alignment techniques for focal plane assemblies having multiple detector array.
- Submillimeter-wave hybrid assemblies for IR astronomy and procedures to enable deposition of both PbS and PbSe on the same substrate to permit two-band IR imaging.
- Integrated circuit design and fabrication tailored to low noise analog with digital components on the same chip.
- Indium bump bonding of detectors to chips or improved technology.
- Very large high voltage detector frames for spark chambers.
- Ultra-large wire-wrapped detector frames for spark chambers or drift chambers.

08.17 Subtopic: Focal Plane Array Processing for Position Determinations

Center: JPL

The history of the Solar System is influenced by the statistics of encounters with passing stars. The traditional detection of nearby stars by their proper (tangential) motion cannot identify stars having velocity vectors towards or from the solar vicinity. As a consequence, the stellar population in the solar vicinity is only partially known. To identify the missing population it will be necessary to measure all stars to find those with parallaxes >0.05 arcseconds. Observation of millions of stars is now within the advanced state of the art of CCD arrays and of data processing and storage technology.

Innovative approaches are needed to develop an instrument and associated subsystems to observe a large area of the sky each year. This instrument would be for testing proof-of-concept on the 1.2 meter F/8 telescope at the NASA-JPL Table Mountain Observatory. Observation modes to be considered include (1) a tracking telescope plus framing mode CCD operations and (2) a fixed telescope and CCD clocking for compensation of sidereal drift rate of the field of view. The concept should also be applicable for a space telescope for a voyage to 1000 AU (TAU). Innovative concepts are desired in the following system and subsystem areas:

- Develop a data collection, management, storage and retrieval concept to handle image coordinates for 105 to 106 starts per night in either the framing or clocking mode. The output display will include stars that show parallax >0.05 arcseconds from position measurements taken approximately 6 months apart, along with position coordinates of the selected objects and the magnitude of parallax and proper motion.
- Develop a CCD camera to maximize sky coverage that is compatible with the concept proposed, assuming that the telescope is used at prime focus and should attain precision measures of stars as faint as magnitude 20. The CCD camera should be optimized for the data collection and management strategy proposed.

08.18 Subtopic: Submillimeter Radiometer and Antennas
Center: JPL

Submillimeter radiometer and antenna technology: Submillimeter radiometers and antennas operating in the 0.1 to 1.0 millimeter wavelength range for space astronomy, astrophysics and atmospheric studies require innovations in the following areas:

- Antenna systems, with apertures up to 4 meters, with multiple beams.
- Focal plane radiometer arrays.
- Cryogenic low-noise radiometers with operating times of 2 years.
- Solid state phase-locked local oscillators.
- Space-qualified, small, low-power spectrometers with up to 10 GHz bandwidth and frequency resolution of 1 MHz.

08.19 Subtopic: Optical Components and Systems
Center: GSFC

In the area of optical components and systems for Earth-orbiting spacecraft/platforms, innovations are needed for the following:

- Optical coatings for use in the extreme ultraviolet to the far infrared spectral region that provide wide and narrow band filters, beamsplitters, polarizers and reflectors.
- Fabrication techniques for high accuracy normal or grazing incidence aspheric mirrors.
- New technologies for producing diffraction gratings for the ultraviolet and soft X-ray region.
- Infrared filters, beamsplitters and polarizers for application in instruments at cryogenic temperatures.
- Apparatus for the measurement of the refractive index of materials as a function of temperature from 273K to 4K. Accuracies of one part in one thousand to one part in ten thousand are needed.
- Bragg crystal technology.
- Means to detect and measure small surface errors on grazing incidence, cylindrical, conic section and high order aspheric surfaces characterized by rapid rate of slope changes. The device(s) must be capable of measuring surface errors in spatial frequency domain of 0.5 to 5 millimeters in spatial extent which have an amplitude range of 0.5 to 5 nanometers.
- Theory and analysis techniques for distortion compensation of large (> 1 meter) optical reflector surfaces using structural models of surface distortion.
- Apparatus and techniques to monitor or control contamination of optical surfaces in space.
- Algorithms for optimization of optical component dimensional and optical specification within a system design.
- Algorithms for diagnosing the effect of optical component misalignment effects on centered and decentered optical systems using output from a two-dimensional detector.
- Devices and techniques for the manufacture, assembly, alignment and testing of optical systems in space.
- High transmission carbon fiber meshes with a large fractional open area to act as a substrate for extremely thin metal filters and to support proportional counter windows against pressure differentials on the order of one atmosphere for application in X-ray astronomy.
- Thin, flat, smooth substrates for X-ray mirrors for application in X-ray astronomy.

08.20 Subtopic: Wind Tunnel Instrumentation
Centers: ARC
LaRC

Innovative concepts and techniques are needed in the following areas of wind tunnel instrumentation:

- Nonintrusive detection of boundary layer transition on models tested cryogenic and other tunnels.
- Advanced Smart sensors for pressure measurement.

- Smart sensors for temperature and heat flux measurements in the range 1800C to 3000C.
- Miniature sensor concepts including pressure, temperature, flow, and shear measurements for both flight and ground test applications.
- Remote, miniature measurement of model angle of attack.
- Miniature, temperature-insensitive null position sensor.
- Measurement of high level strains at temperatures above 1100C.
- Computer-controlled travelling and survey probes.
- Nonintrusive measurement of mean and turbulent flow properties and gas composition in the test sections of wind tunnels over a wide range of flow conditions.
- Remote measurement of flow properties in the vicinity of models, including innovative holographic techniques.
- Multiprobe concepts for pattern recognition and image enhancement.
- Spectroscopic flow-field visualization schemes.
- Nonintrusive global techniques for measuring fundamental flow field parameters.

08.21 Subtopic: Aeroheating Flight Instrumentation
Center: MSFC

The use of plug-type calorimeters to measure aerodynamic heating on spaceflight vehicles is common practice. Usually these sensors are surrounded by thermal insulation material. Due to differences in surface temperature between the insulation and the calorimeter face, the measured data must be analytically corrected to provide a prediction of the actual aeroheating environment. The existing methods for this correction introduce large uncertainties that compromise these expensive measurements. Innovations are sought for aeroheating instrumentation that minimize or eliminate the correction required due to surface temperature mismatch between instrument and adjacent materials.

TOPIC 09.00 SPACECRAFT SYSTEMS AND SUBSYSTEMS

09.01 Subtopic: Control of Large Space Structures
Center: LaRC

Future space missions are expected to require large spacecraft which are loosely coupled and highly flexible. These spacecraft will require control systems and components which are more reliable and more efficient than current systems. The objectives of this subtopic are innovations in (1) advanced control system analysis and synthesis techniques; (2) fault identification, isolation, and reconfiguration; and (3) advanced integrated control systems and associated components. The focus should be on both control system design and control devices and may involve ground validation of advanced system concepts and attendant breadboard hardware.

09.02 Subtopic: Space Construction and Maintenance Tools and Techniques
Center: JSC

Innovations are needed in the following for construction, repairs, and maintenance of structures and mechanisms in space:

- Welding and bonding: Techniques and devices compatible with the space environment which are operable by an extravehicular crewman that provide for fastening and joining of metallic and nonmetallic materials.
- Electrical cable and fluid plumbing: Techniques and devices compatible with the space environment which are operable by an extravehicular crewman that provide for splicing, cutting, joining, and forming of electrical cables and fluids plumbing.
- Plate and structures modification: Techniques and devices compatible with the space environment which are operable by an extravehicular crewman which provide the capability for sawing and drilling of metallic and non-metallic materials with collection of particle debris.
- Alignment and measurement: Techniques and devices compatible with the space environment which are operable by an extravehicular crewman which provide precise alignment of mating structures and measurement of relative distances upon and between object surfaces.

09.03 Subtopic: Space Station Crew Workstation Displays and Controls
Center: JSC

The workstation design for a future Space Station must incorporate state-of-the-art display and control technologies and must provide a friendly and flexible user/machine interface. To accomplish this, innovations are needed in the following areas:

- Multicolor flat panel electronic displays: Currently available flat panel displays for Space Station applications offer only monochromatic capability. A small-volume, low-power, multicolor, flat panel display is needed.

- Input devices: Develop input devices and mechanizations that (1) are simple to use; (2) the communication language results in high user efficiency; and (3) are reliable and easy to maintain.
- Data storage: Develop high density local workstation data storage aids such as optical disks, disk RAMs, floppy disks, bubble memory, etc.
- Voice recognition: Develop a voice system for data and command input that is voice independent, can understand word phrases, has a large vocabulary and has a 99% or greater accuracy rate.
- Hand controller: Develop compact hand controller devices with force feedback that could be used to support six degree-of-freedom master/slave type telerobotics space operations.

09.04 Subtopic: Manned Spacecraft and Planetary Base Thermal Management Systems

Centers: JSC
MSFC

Future large space systems will include two-phase heat transport circuits to improve the efficiency of the thermal management system by utilizing the fluid's latent capacity for energy storage. Innovations are needed in the following heat acquisition, transport, and rejection areas:

- Non-toxic thermal fluid: A non-toxic thermal fluid is needed which has a high heat of vaporization, low freezing point, high vapor pressure, high thermal conductivity, and good capillary characteristics.
- Advanced high temperature heat pipe: Innovations are sought in high temperature (above 200F) heat pipe design for potential applications in large space radiator systems for advanced manned spacecraft missions and lunar base applications using subsystems with high operating temperatures such as solar dynamic power cycle.
- Advanced space radiator systems: Innovative approaches, such as vapor compression systems, novel high capacity heat pipe radiators, moving belt radiators, or liquid-droplet radiators are required to reduce overall system mass and size while increasing system efficiency and thermodynamic performance in support of future manned missions, such as Lunar Base or Mars Expedition.
- Two phase fluid flow measurement technology: Innovations for measurement of quantity and flow rate of a two-phase fluid flow in a zero gravity or low gravity environment are required to provide vital information for control of advanced thermal control systems.
- Waste heat utilization: Innovative and efficient approaches are sought to utilize low or medium temperature waste heat generated by spacecraft systems for heating, heat pump, and power generation applications.
- Refrigeration concepts are sought, which satisfy safety issues relative to manned environments, to accommodate low temperature requirements of long term storage of food and biological samples.
- Heat pump systems are sought which are compatible with safety issues relative to manned environments, to accommodate high temperature requirements for heated water for crew hygiene (shower, clothes and dishwater, etc.).

09.05 Subtopic: Thermal Control for Unmanned Space Applications

Centers: GSFC
MSFC

Future unmanned spacecraft equipment will have higher power levels, longer transport distances, higher temperatures and will require closer temperature control than current space systems. Such characteristics may be particularly applicable to scientific instruments, power generating equipment, materials processing, and surface transportation vehicles. Many missions will be farther from Earth and of long duration.

These conditions will place increased requirements on thermal control systems, including increased efficiency, reliability, compatibility and synergy with other mission functions, low maintenance and where appropriate, self-repair capabilities. Consequently, innovations in every aspect of thermal control are desired which can better achieve these desired characteristics appropriate to specific missions and applications. Areas of interest include, but are not limited to, the example technology areas and concepts listed below.

- Fluid systems technology:
  —Modelling of multiphase flows, and flow measurement techniques in zero or low gravity;
  —Detection of very small leaks in multiphase systems;
  —High temperature (1000K) long-life heat transport devices;
  —Cryogenic heat pipes;
  —Heat pipe evaporator interfaces including contact heat exchangers, integral heat exchangers or heat pipe disconnects;
  —Space radiator concepts and design innovations, including systems integral with spacecraft exterior structure;
  —Radiator coatings or concepts to provide self-sealing;

—Modular, self-contained heat pump to allow equipment to operate at temperature close to, but different from, the saturation temperature of a central two-phase thermal bus.

- Special thermal system capabilities:
  —Waste heat utilization of low or medium temperature waste heat generated by spacecraft systems for heating, heat pump, and power generation applications;
  —Thermal energy storage system which periodically charges and discharges to accommodate intermittent heat loads;
  —Integration of thermal and power subsystems to minimize total energy requirements. An example would be use of an absorption cycle cooling system by waste heat from a power or materials processing system.

09.06 Subtopic: STS Power Control and Distribution Subsystems

Center: JSC

Innovations are needed in the following areas pertaining to STS subsystem in the area of spacecraft power and control:

- Solid state high power switching components: In order to handle large amounts of power on new spacecraft and to provide the necessary instrumentation to support expert systems, "smart," computer-controlled, high power switching components need to be developed.
- 20 kilohertz AC signal conditioners: The use of high frequency electrical power for space applications creates the need for new instrumentation signal conditioners (SCs). The SCs must be applicable for voltage, current, frequency, phase, and power factor measurements in the AC circuits with voltage levels up to 600 volts and at frequencies up to 20 kilohertz.
- High-efficiency 400 Hz converters: New spacecraft require devices that can convert DC or unregulated AC into 400 Hz power and provide maximum efficiency with minimum practical weight.

09.07 Subtopic: STS Tracking Systems

Center: JSC

Innovations are sought in millimeter and electro-optical spacecraft tracking systems as potential replacements for conventional microwave systems. Such systems are required to support spacecraft terminal rendezvous, station-keeping, and docking. Innovative laser tracking/vision systems to support robotics and automation space applications are also needed for future NASA missions.

- Solid state laser scanning device: The need exists for new and novel ways of scanning a narrow laser beam over a larger field of view. New approaches for doing this with no mechanical parts are sought.
- Hand-held optical radar: Recent studies have indicated that hand-held in- space optical radar can be built using new modulation techniques which enable operation over long distances in full sunlight.
- High resolution millimeter-wave radars/radar subsystems: Light weight, low power radar systems are needed to solve various short range, rendezvous, station-keeping, and target tracking problems during manned and unmanned space operations. These operations will require higher tracking resolutions than are generally available. Examples include navigation aids for the Manned Maneuvering Unit (MMU), the Orbital Maneuvering Vehicle (OMV), and other proximity operations involving deployed satellites and scientific payloads.
- Laser diode Lidar systems for ranging and velocity information.
- Optical sensor systems for pattern recognition, ranging and vision.
- New signal processing techniques and hardware.
- Improved optical components such as sources, detectors, couplers, switches, modulators and lenses for imaging systems.
- Laser tracking/vision sensors for automation and robotics applications.
- Precision star catalogs for solid state imaging star trackers: A need will exist for large, precise catalog of stars for use in sub-arc-second pointing applications with CCD/CID (charge coupled device/ charge injection device) based spectral response star trackers.

09.08 Subtopic: Tether Applications in Space

Center: MSFC

Tethers have potential roles in space in forming constellations of spacecraft and as one-dimensional structures. Applications concern power and force generation through motion in the ionosphere, spacecraft docking assist, formation flying of and momentum transfer between tethered spacecraft. Innovative uses of tethers in space and engineering approaches to tether deployment and retrieval problems are desired. In addition, innovative combinations of tether materials and protective or conductive coatings that adhere when stretched are needed.

- Tether materials testing, properties measurement and research:
  —Tether materials testing and research have been accomplished for a very narrow range of applications under the Tethered Satellite System project. Even in that program, tether dynamical properties

such as viscous and coulomb damping under various tension and temperatures have not been studied in detail. Testing of tethers is difficult because some measurements require vacuum testing of long lengths implying a long vacuum chamber. Measurements in the presence of gravity also present difficulties when low tension is one of the important parameters. Research into the design of tethers to enhance performance such as achieving large amounts of damping could enhance overall performance of tether systems.

- Sensors for space tether systems:
  —Applications of space tethers usually involve a requirement to measure tether tension. Present sensors employ a device which deflects the tether, such as an idler wheel, and the strain exerted on the wheel support is detected by a force transducer. Measurement of tension over wide dynamic ranges is a problem with such devices and the devices add a certain amount of error into the system because of the necessary contact with the tether. An innovation is required in the design approach to overcome these deficiencies.
- Tether demonstration flights:
  —Tether system safety concerns limit the amount of experimentation which can be performed in space using the Orbiter as one end of the tether system. Satisfying the safety requirements can result in a large amount of ground testing, expensive safety controls, redundancy, and time-consuming crew procedures and training. Innovative approaches to satisfying or alleviating these safety requirements would result in less expensive tether flight experiments and quicker development of tether technology and applications.

09.09 Subtopic: GAS, ELV and Spartan Systems
Center: GSFC

A simple, innovative, economical, expendable spacecraft is required to provide an orbiting platform for space-based commercial use. This will be a single strand, one experiment free-flyer that can be ejected from an STS flight or an ELV. This ejected cannister shall be an 18-inch high cylinder, 19-inch diameter, weighing less than 150 pounds, and may have solar cells on the 18-inch-high cylinder walls. This subtopic solicits innovative approaches for the design, construction and qualification of any or all the following:

- GAS cannister system: Assuming sufficient power collection in orbits up to a 40 percent umbra, provision shall be made to store solar power and provide 2 watts average power to internal functions and 50 watt hours per day to the single experiment with a peak power of 50 watts. The spacecraft shall contain an innovative propulsion system with a single nozzle aimed at the cylinder axis at the bottom of the cannister. One cubic foot and 50 pounds of the 150 pound total weight shall be reserved for the experiment.

  The spacecraft shall have VHF PCM convolutionally coded, phase-modulated telemetry, UHF PCM commands, 24-hour stored command memory, 10^7 bit solid-state memory with EDAC for command telemetry data storage, passive thermal design, STS separation timer, end-of-life timer, omnidirectional antenna system, and ability to operate from a single ground station. This single ground station shall be simple, portable, user-owned and operated, with an omnidirectional antenna and shall be designed, fabricated, and provided with this effort. NASA facilities may be used for qualification and acceptance activities. One hundred percent commercial solid-state parts shall be used with their only qualifications being completion of 500 hour period of prelaunch satellite operation with no failures.
- For Spartan and other free-flying spacecraft, when operating close-in the orbiter or Space Station and when there is a need to communicate from one to the other, use of standard spacecraft frequencies such as S-band can lead to difficulties. The short wavelengths involved guarantee interference dropouts, multipath-path phase distortion and shadow drop- out. When wavelength is long with respect to the largest physical dimension involved, these problems are much diminished.

  Innovative techniques are required in the application of the LF through HF use as a carrier for data communication in the one kilometer and less range between spacecraft. Phase I should address advantages, i.e., sensitivity, reduced emitted interference, low operating power and concerns, i.e., physical versus electrical size of antennas, limited data bandwidth, earth-generated interference.

TOPIC 10.00 SPACE POWER

Subtopics 10.01 and 10.02 represent two application areas of space power systems technologies. Innovations are desired in all aspects of solar photovoltaic, solar thermal and nuclear (excluding the reactor) power systems. The primary difference between the two subtopics is specific application and emphasis. The disciplines and technologies of interest are listed below:

- Energy Conversion Systems
  —Photovoltaic systems technology; thin GaAs cells; homojunction and heterofaca cells; recombination effects; radiation resistant cells and approaches for reducing radiation effects; welding of cell interconnects;
  —Brayton, Rankine, Stirling cycle technologies; alternator concepts; advanced solar concentrators/mirrors with associated structures; heat receiver technologies.
- Energy Storage Systems
  —Electrochemical; advanced fuel cells, primary and regenerative; advanced high energy density rechargeable batteries (excluding lithium);
  —Thermal storage; receiver and heat storage concepts for solar thermal power systems;
  —Advanced energy storage concepts beyond the present state of the art.
- Power Management and Distribution Systems
  —Materials for power electronics;
  —Electronic devices; transformers; diodes; transistors for high current, high voltage, high frequency distribution systems;
  —Control of high voltage-high power systems.
- Thermal Management and Control Systems
  —Advanced lightweight heat pipes for high and low temperature ranges;
  —Innovative thermal management and control concepts.
- Interactions with the Space Environment
  —Free oxygen; chemical species interactions;
  —Interaction with the space plasma.
- Automation and Control of Large Space Power Systems
  —Innovative traditional/classical approaches to system control;
  —Application of expert systems and artificial intelligence logics to power system operation and control.
- Materials for Space Power Systems
  —Materials which enhance the performance and durability of advanced space power systems through reduced degradation with the space environment, operate at higher temperatures, enhance compatibility between materials, and reduce interactions with the space environment.
- Systems Analysis and Design
  —Methodologies for the design and analysis of space power systems with emphasis on ease and simplicity of use, ability to handle all types of realistic constraints;
  —System and subsystem simulations to analyze design sensitivities, including off-design performance;
  —Computer codes to assess performance and cost effectiveness.

Emphasis is on innovative concepts and applications which increase efficiency, decrease size and weight, enhance operating lifetime, manufacturability, and verification testing of systems and components. Advanced concepts beyond the present state of the art which have potential for "cost effectiveness" for a wide range of applications—Earth orbital missions, interplanetary missions, or planetary installations—are the primary thrust of these subtopics.

10.01 Subtopic: Large Scale Space Power Systems

Center: LeRC

Innovations are sought in the area of large space power systems for permanent space station installations, orbiting platforms, and large power systems for planetary transfer vehicles and/or planetary installations. The stations/vehicles may be manned or unmanned and maintainability and in-situ repair are important considerations. Autonomous operation, or operation requiring a minimum of astronaut intervention is of prime importance.

10.02 Subtopic: Spacecraft and Planetary Rover Power/Energy Systems

Center: LeRC

Innovations are sought in the area of power/energy systems for future spacecraft and planetary rovers. These systems are, as a rule, unmanned, requiring long lifetimes. Autonomous unattended operation is also a consideration, while a compactness and high energy/power densities are prime requisites.

TOPIC 11.00 SPACE PROPULSION

11.01 Subtopic: Solid Rocket Motor Technology

Center: MSFC

A. Reliability of Composite Components

Several areas of solid rocket motors require innovative advances in analytical design and test disciplines to gain reliability improvements.

- Quantitative methods on which to base acceptance or rejection of carbon- carbon parts, carbon-phenolic parts, and filament wound composites: Methods that relate directly to the strength and thermal capability requirement rather than to qualitative assessment that the material has undesirable features of voids, dry plys, wrinkles, low density indications, and surface colorations.
- Criteria and methodology based on material properties which allow analytical and test verification of nozzle margins of safety in heat affected and virginal areas.
- eans to assess tolerance of filament wound composite (FWC) cases to damage incurred in handling or manufacturing. Cases should not routinely be scrapped without adequate analytical- and criteria-based testing to confirm capability.
- Failure criteria for FWC cases, implemented in an algorithm for predicting failure, and demonstration of algorithm validity in predicting failure after case exposure to nominal design loads with five pressurization cycles.
- Means to evaluate and measure stress in FWC case pre- and post-cure and during design loading. Determine role of residual stresses in design load capabilities of an FWC case.

B. Thrust Vector Control

The future use of solid propellant rockets as space boosters will require significant cost reductions. The thrust vector control (TVC) systems used on the two largest boosters now in use are the flexible nozzle seal with hydraulic actuation and liquid injection TVC. Because both systems are expensive, heavy, and complex, innovative improvements are sought. One approach could be a fixed nozzle with mechanically inserted probes to disturb the flow and cause thrust vector deflection. Two areas of innovative investigation are needed. The first is to determine analytically the degree of thrust vector deflection that can be effected by probe insertion. The second is to determine what existing materials are suitable for use in the extremely severe environment inside a solid propellant booster nozzle.

11.02 Subtopic: High Performance, Long Life Small Chemical Rockets

Center: LeRC

New space system capabilities, such as spacecraft propellant resupply and use of Space Station waste fluids to augment platform propulsion, and more energetic, longer life missions have greatly expanded the leverage for improved rocket lifetime and performance. Advanced technologies for small, radiation-cooled rocket chambers are sought which have promise of extending chamber lifetimes and simultaneously operating at increased specific impulses. Concepts are desired which are compatible with a variety of potential propellants, including H/O, Earth storable, and monopropellants augmented with Space Station waste fluids.

Innovative materials, coating technologies, fabricating technologies, and chamber/injector designs are sought to achieve long-life, highest possible performance, and propellant flexibility with minimum design changes. Chambers approaches compatible with fundamental diagnostics and which can be tested with minimum costs are especially desired. Government facilities will be made available for proof-of-concept and extended life tests.

11.03 Subtopic: Rocket Engine Combustion Processes

Center: MSFC

Current state-of-the-art CFD combustion codes have deficiencies in fundamental physical models as well as being incapable of handling certain specific applications important in liquid rocket engines. Enhanced capabilities are particularly sought in the following areas:

- Fundamentals
  - —Spray atomization characterization modeling to better simulate injector geometry effects upon combustion;
  - —State-of-the-art modeling of the droplet-wall and droplet-droplet interaction. Characterization of supercritical spray combustion;
  - —Improvement of chemical reaction simulations;
  - —Incorporation of state-of-the-art turbulence and turbulent combustion modeling;
  - —Incorporation of improved differencing techniques to reduce numerical diffusion.
- Applications
  - —Time accurate solution techniques that enable modeling of the rocket engine start-up and shutdown;

—Thermal analysis capabilities to predict the axial wall temperature profile, taking into consideration the coolant flow in combustion chamber wall processes and return of the heat/energy to the injector face;

—Modeling of LOX/Hydrocarbon combustion environments.

The approach to the achievement of these topics should be innovative and mathematically rigorous, avoiding empiricism as much as possible.

Rocket engine performance and stability prediction programs require injected propellant drop size information and fuel mass flow profiles resulting from the propellant injection process as input data.

- A measurement technique/procedure is needed to determine the mass flux (amount of fluid per unit area in a plan normal to the flow field axis) of both the oxidizer and fuel flowing from an injector element where one propellant is injected as a liquid and one is injected as a gas. The ability to obtain measurements at numerous locations throughout the spray field is required. Generally the measurements would be made across a plane approximately 2 inches below the face of a single element injector under cold flow, noncombustion conditions. Later measurements using single element injectors under combustion conditions are desirable.
- An analytical model is needed which can predict injected propellant drop size as a function of injector element design parameters and propellant properties and injection conditions. The model capability needs to include both liquid and gaseous propellant injection and impinging and coaxial injector element configurations.

11.04 Subtopic: Liquid Engine Internal Flow Dynamics

Center: MSFC

To enable design and optimization of present and advanced liquid-fueled rocket engines, innovative techniques are sought for modeling internal flows and for coupling the structural and fluid dynamic behavior. Specific improvements required are:

- An innovative computational technique to couple a three-dimensional time-dependent fluid flow solver and a three-dimensional structural model. The technique must account for flow separation and shock wave boundary layer interaction, and must incorporate a moving grid system for structural deflections.
- Innovative computational models of combustor flow including liquid atomization of shear coaxial and swirl injector elements, spray droplet thermodynamics near the critical point, and turbulent mixing and droplet dynamics of atomized spray in a chemically reacting flowfield.
- Techniques for treatment of complex incompressible three-dimensional vaned element flows in turbopump inlet and exit housings.
- Advancement of analysis techniques for incompressible three-dimensional vaned rotating flows with phase change for turbopump bearing and damping seals.
- Improvements to viscous flowfield calculation procedures to account for nonisentropic boundary layers in regeneratively cooled nozzles.

11.05 Subtopic: Experimental Fluid Dynamics of Rocket Engines

Center: MSFC

A number of innovations in nonintrusive measurement techniques are needed to accurately measure and understand the flow through simulated ducts and chambers of a rocket engine. These measurements would assist in the analysis of engine performance and comparison with computational fluid results. Examples of innovative ideas that require additional research in the area of measurement technology are:

- Development of one-, two-, and three-component laser-Doppler velocimeter systems for measuring complex fluid flows through simulated engine components.
- Development of laser-enhanced water tunnel flow visualization techniques and computerized data reduction systems.
- The flow in the stationary passages of flow machinery, e.g., in liquid propellant rocket engines upstream of the combustion chamber, is often very complex, and local flow directions are not known a priori. In order to eliminate the need for sensor alignment to this unknown flow direction, sensors are required that can accurately measure the velocity vector at large angles to the sensor, say 70 to 80 degrees. The sensor design may conceivably be based on the multihole pressure principle, or on the single/multi hot wire/hot film principle; other principles are not excluded. The sensors are to be operated in incompressible flow.
- Laser-Doppler velocimetry promises to be a convenient tool for measuring fluid flow characteristics in transparent models of stationary or rotating machinery elements, such as the complex flow passages in liquid propellant rocket engines upstream of the combustion chamber, or the propellant pumps of these engines. Optical distortion of the beam is a primary impediment. It can be eliminated by using a model material and operating

fluid combination with identical indices of refraction. Glasses and plastics offer themselves as model materials. Plastics appear preferable from a manufacturing and operational point of view. Fluids should preferably be non-toxic and non-flammable.

TOPIC 12.00 HUMAN HABITABILITY AND BIOLOGY IN SPACE

12.01 Subtopic: Environmental Control and Life Support Systems

Center: JSC

Innovations are needed in the following areas of environmental control and life support to increase human productivity and system performance capabilities for inhabited and space suit environments:

General:

- Carbon dioxide/humidity removal: New techniques are needed to remove carbon dioxide and/or humidity from inhabited and/or space suit breathing air while maintaining the CO atmospheric level below 1.0 mmHg. Experimental data demonstrating the approach effectiveness is desired.
- Oxygen recovery: Regenerable approaches for direct conversion of carbon dioxide with recovery of metabolic oxygen are needed. High conversion efficiencies and convenient removal of product carbon are necessary.
- Zero gravity phase separation: Compact, reliable, low power techniques to separate gas (e.g., air) from a water transport loop in a zero or low gravity environment are needed, for example, to prevent water pump cavitation.

Inhabited Environment:

- Trace contaminant control: Current methods of airborne trace contaminant control include catalytic oxidation, LiOH absorption and charcoal adsorption. Methods must be found to reduce and eliminate production of toxins when using these techniques. Experimental research is needed to determine an effective means to completely remove noxious toxic contaminants which are products of thermal decomposition of trace amounts of halogenated hydrocarbons entering a catalytic oxidizer. Alternate airborne trace contaminant control methods, which do not produce hazardous contaminants, should also be developed.
- Waste water treatment: Current methods of stabilizing spacecraft waste waters (urine, wash water, and humidity condensate) for ammonia and bacterial control include a combination of acid and/or biocide pretreatment prior to storage and processing. Other treatment schemes are required to eliminate the overall complexity associated with chemical treatment techniques.
- Recovered water post-treatment: Reclamation of waste waters, e.g., urine and hygiene water, requires final polishing and bacteria control. Present methods include treatment with carbon and ion exchange beds and maintenance of a 2 ppm iodine residual. Refinement of current techniques and/or a new innovative approach is needed to prevent bacterial growth and to take out contaminants not normally absorbed by conventional sorbent beds without adding toxic agents to the water or affecting purification by the post-treatment beds.
- Understanding of bio-fouling: The variety of microbial growth support by spacecraft waste water presents new problems in the design of water reclamation systems. Among those problems which must be understood are the long-term effects of microbial contamination on plumbing systems and related cleaning requirements.
- Water quality monitor: Methods to monitor the quality of reclaimed water in a regenerative life support system are required. Important parameters include: conductivity (0.06 to 2.0 microsiemen/cm), pH (2 to 8), organic content (1 to 10 ppb), and ammonia (0.1 to 10 ppm). Emphasis should also be placed upon reliability and simplicity of technique and the elimination of expendable reagents.

Space Suit Environment:

- Advanced information systems: Techniques to provide a low-profile, easy access, low-power information display system to working suited crew members are sought to convey life support, caution/warning, and procedural text/graphics necessary for routine servicing scenarios. Extravehicular crew members currently receive life support information from a chest-mounted 12 character display. Current efforts include the development of a CRT and LCD virtual-image (see-through) helmet mounted display. Consideration should be given to space sun and night environments.
- Extravehicular portable heat-rejection techniques: Compact, reliable, low-power, non-venting (e.g., water vapor) techniques to facilitate efficient thermal rejection of an extravehicular crew member's metabolic and life support generated heat load are required.
- Self-adjusting helmet visor solar protection: Techniques are sought to provide automatic am-

bient light sensing and correction into an extravehicular crewmember's solar visor assembly to eliminate the need for manually deployable solar shades in high sun environments.

12.02 Subtopic: Waste Water Reclamation and Monitoring for Space Station
Center: MSFC

Reuse of waste experiment water is required to reduce the substantial resupply penalties associated with laboratory operations in the Space Station. Routine monitoring of the microbial state of various reclaimed waters will be required on board long duration manned space missions. Required sensitivities in the range of 1 cfu/100 ml, or below, preclude the use of currently available online monitors in favor of more labor intensive techniques.

- Innovations are sought that will lead to the development of a subsystem capable of reclaiming various experiment waste waters for subsequent reuse. As a goal, it is desired to produce water equivalent to ASTM Electronics Grade E-1 with a pyrogen level not to exceed that defined in USP XXI. Minimum subsystem weight, power, and volume along with maximum reliability, flexibility, and commonality is required.
- Innovations are required which will lead to the development of an automated, on-line monitor capable of near real-time measurement of microbial contamination in the range of 1 cfu/100 ml or below. Emphasis will be placed on reliability and accuracy as well as minimum crew involvement, sample size, and expendable usage. Contamination of the processed water supply via the monitor shall be prevented.

12.03 Subtopic: Medical Sciences for Manned Space Programs
Center: JSC

As the goal of permanent occupancy in space becomes a reality, there exists a need for providing a wide range of medical services to space crew members.There is also a continuing need for maintaining excellent health of astronauts during their preflight periods and for profiling their health characteristics. Many areas of medicine are candidates for innovations:

- Analysis of small volume specimens.
- Determination of decompression sickness before significant symptoms occur.
- Measurement of changes in bone mineral and muscle status over short term intervals (weeks-months).
- Measurement of changes in immune system over short periods and quantify effect of stress and radiation.
- Operational solutions to the problem of Space Adaption Syndrome including effective countermeasures, reliable and predictive tests, and understanding of the mechanisms of space motion sickness.
- Automated portable multi-gas sampling gas chromatograph.
- Ways to estimate circulating red blood cell mass during flight.
- Simple means to measure mass of crew members and of biological samples in microgravity.
- Imaging devices including magnetic resonance, X-ray, and ultrasound.
- Simple rapid determination of a micro-organism causing disease in crew members and/or estimation of its antibiotic sensitivity.
- Constitution and administration of fluids intravenously in a microgravity environment.
- Storage, constitution and administration of blood or blood substitutes.
- Computerized scanning device for diagnosis of disease/trauma in multi-organ systems.
- Oscillatory tooth remover for extracting human teeth. Other innovative zero-g dental hygiene devices.
- Systems for assessment of gastrointestinal function during extended spaceflight.
- Space microgravity bioreactor.
- Automated devices for measuring drug countermeasures in blood, urine, etc.

12.04 Subtopic: Human Factors for Space Crews
Center: JSC

To allow crew to perform routinely in-space maintenance, construction, mechanical, and electrical servicing, plus any and all blue and white collar jobs, innovations are required in order to enhance human capabilities and to optimize crew usefulness. Innovations are also required to enable optimum spacecraft layout/arrangement. Examples of innovations desired are:

- Means to provide data on biomechanical kinematics and dynamics for use in theoretical and applied design models in zero gravity.
- Methods to define, reduce and/or control spacecraft noise (e.g., materials, interior arrangements, crew aids) are desired, with consideration given to weight and volume penalties.
- Techniques for display of and interaction with multiple dimension data, such as multiple parameters of triply redundant systems. Volume and weight must be considered.
- Method to evaluate function allocation between crew members and automation using an expert

system. The system would be required to elicit or generate and weight data on such factors as development time and cost for automation, degree of risk or crew unpleasantness, frequency of function performance, cost savings per performance and safety and reliability of automated systems.

- Techniques for facilitating the layout and arrangement of spacecraft interiors to promote effective and efficient use of the zero-g environment in carrying out living and working tasks.
- Techniques for optimizing spacecraft interior decor. Considerations must be given to the spacecraft environment and mission/operations constraints, including weight, power, materials, and crew time.

12.05 Subtopic: Intravehicular Systems for Space Crews

Center: JSC

The advent of advanced space and planetary missions demands new systems to increase the productivity and performance of the crew. The increased number of crewpersons coupled with extended duration missions will require innovative crew equipment systems. Some areas of potential innovations include:

- Crew hygiene: Systems for male and female body and hair grooming, oral cleansing, and shaving under microgravity and closed environmental systems conditions.
- Temporary solid trash handling: Systems for collecting, deodorizing, storing, and packaging of paper, food scraps, plastic wrappers and other solid trash for processing onboard manned space vehicles.
- Equipment tracking and management: A system for identifying individual tracking location, availability, usage, and individual stowage location for all crew equipment. This system must be flexible, efficient, and failsafe automatic, requiring minimal crew input. This system not only should identify individual item stowage locations, but should also provide an immediately accessible quantity/item-quantity remaining balance for crew expendable items to coordinate ground operations with inflight needs and usage.
- Still imagery: Electronic still frame recording device for use in microgravity with high resolution capability and image recorded on a removable recording/playback media. The system must be small and compact, and portable for crew operations. It shall record in the visible spectrum with resolution approaching a 35mm still frame of film. Also needed are a means for the electronic transmission of still frame images from orbit to a ground receiving station and a recorder/processor capable of processing the image data on film (either negative or positive) or providing paper prints.
- Data transmission: Means of providing transmission of data, graphs, and photographs both uplink to orbit and downlink to the ground.
- Visual observation aids: Means to provide high resolution visual observation of various portions of the Space Station from the crew module. System to have the capability of observation when manipulating robotic elements, observation of EVA crewmembers, and for the inspection of objects nearby and some distance from the orbiting vehicle.
- Food production: Techniques for using Lunar or Martian materials for food production should be identified. A combination of production techniques as hydroponics, aeroponics, and terraponics should be investigated to produce an optimized strategy. The impact of such techniques in closing the life support system should also be addressed.
- Food storage: Techniques and methods for extending the shelf-life of fresh fruits and/or vegetables.
- Food system automation: Uses of automation are needed to reduce the amount of time a crew member must spend in food-related activities such as preparation, clean-up, inventory, or resupply.
- Food systems: To enhance the interface between man and the food service system during extended Space Station habitation, techniques adaptable to a microgravity environment for packaging, preparing and serving solid and liquid foods are required to provide a functional system.
- Space farming: Techniques and equipment for growing, harvesting and preparation of edible foodstuffs in space will be required for permanently manned Space Stations.

12.06 Subtopic: Animal and Plant Life Support and Protective Systems

Center: ARC

Non-human payloads provide basic scientific information on the response of living systems to the space environment as well as possible explanations of the human response and adaptation to space. Innovation is sought in areas which will enhance or enable the full flight experiment potential of unicellular organisms, animals and plants through improved care, support, observation and monitoring techniques for the Space Station.

- Implant telemetry for direct biosystem monitoring or control.
- General improvement in physiological monitoring techniques for inflight and ground studies of cardiovascular, skeletal, vestibular, hematological,

reproductive, and other changes occurring during spaceflight.

- Automated food delivery and waste management systems for measuring food and water consumption as well as waste product monitoring, volume collection, sampling and storage. Also metabolic holding facilities for rodents to permit complete waste collection and gas exchange measurements.
- Plant growth chamber designs incorporating control of irradiance, temperature, humidity, carbon dioxide concentration and watering in microgravity.
- Small scale breeding facilities for spaceflight use with animals such as monkeys, rats, mice, and frogs.
- Environmental control and monitoring systems applicable to various species for maintenance of desired temperature, humidity, vibration, atmosphere and other factors during spaceflight.
- Application of various techniques and hardware to zero-g conditions, such as animal holding and husbandry facilities, incubators, surgical techniques, wet chemistry processing, biochemical analysis, and continuous flow processing for aerobic and anaerobic fermentation.
- Centrifugation technology to provide an artificial gravity environment during spaceflight and a research tool for biological studies in microgravity.
- Techniques applicable to contamination, control, contamination monitoring, biosolation, etc. (e.g., cage cleaner).

12.07 Subtopic: Biological Sciences Operations

Center: KSC

Innovations are required in a number of areas to support the conduct of research and biological sciences in space. These areas include:

- Improved methods and techniques of laboratory support for specialized plant and animal studies.
  - –Monitoring substances to detect plant and animal stress in sufficient time to treat the problem;
  - –Maintenance of animals in a specific pathogen-free or gnotobiotic condition while housed in ground facilities;
  - –Remote environmental sampling instrumentation, innovative sampling methodologies for biospecimens, microprocessor control systems, and software packages for data analyses;
  - –Compact, energy efficient subsystems to process waste and inedible biomass into acceptable food products or forms reusable by plants for recycle;
  - –Nutrient delivery systems for higher plants, both fibrous and tuberous root systems;
  - –Robotic subsystems to seed and harvest plants;
- Development of flight hardware for plant and animal experiments aboard spacecraft.
  - –Miniaturized and highly reliable nutrient delivery systems for plants and animals;
  - –Automated atmospheric monitors with ultra low level trace contaminant capabilities;
  - –Methods to generate and provide lighting for plant growth aboard spacecraft at low levels of power;
  - –Effective waste management systems which can be effectively miniaturized;
- Specialized research to solve specific problems anticipated for space applications, such as:
  - –Accurate and continuous control of lighting and environmental variables for plant growth units;
  - –Tissue culture techniques, both ground based and space based;
  - –Individual "on-demand" nutrient delivery systems to optimize plant growth and animal feeding;
  - –Computer subsystems to identify plant diseases;
  - –Genetically improved plant material to maximize food yield over time;
  - –Techniques for growing plants with special capabilities (e.g., salt tolerant plants using urine for condensation/recovery by evapo-transpiration; removal of toxic substances from the atmosphere).

TOPIC 13.00 QUALITY ASSURANCE, SAFETY AND CHECK-OUT FOR GROUND AND SPACE OPERATIONS

13.01 Subtopic: Ground Operations Instrumentation

Centers: KSC
JSC

Ground testing and launch of space hardware involves measurement of a large number of parameters in a field operations environment. Following are examples of areas in which new, innovative approaches are sought:

- Contamination Detection
  —Reliable, traceable calibration of commercial Aerosol Particle Monitors for particle counts as well as for particle size. Current methods provide size calibration, but do not provide absolute calibration of particle count;
  —A non-contact instrument that can determine the quantity of organic contamination on metal surfaces. The instrument must be able to monitor surfaces as small as 0.04 square inch, be insertable into 1/4-inch pipe, extend at least 5 feet, and be sensitive to 1 mg/sq ft of organic contamination;
- Hydrogen/Oxygen Detection
  —High reliability, low maintenance H_2 gas detector with range of 0-8% which can operate in air, N_2, He, or changing mixtures of all three. Portable meter and fixed 0-5 VDC sensor needed;
  —Improved mass spectrometer-based system for detection of trace or % LFL (lower flammability limit) H_2 and O_2 levels. (Detect H_2-10 ppm to 4%; O_2-10 ppm to 4%; He-1 ppm to 10%; Ar-1 ppm to 1%.) The technical challenge is to meet or exceed present analytical capabilities (computer-controlled quadrupole mass spectrometer with triode ion pump) with pumping capabilities which (a) survive launch vibration and (b) do not become saturated with hydrogen within 4-6 months. Improvements are sought in (a) high vacuum pumping techniques, (b) ionizer design and (c) data handling techniques;
  —Multispectral color TV for hydrogen fire detection: Develop color television system capable of imaging and displaying hydrogen fires with normal ambient background, including full daylight with open sky background;
  —A reliable fire detector that will safely and reliably detect burning hydrogen flowing at 5 liter per minute source through a 1/16 inch orifice at a distance of 100 feet and not be subject to false alarms. This miniature UV fire detector will utilize the state-of-the art technology to maximize the usable lifetime of the unit;
  —Provide the capability for remote sensing and measurement of hydrogen concentration. Depth resolution of less than 10 feet and concentration resolution of 5000 ppm is sought. High data rates are needed to cover a 100 feet by 100 feet by 50 feet volume in 2-3 seconds;
- Toxic Vapor Detection
  —Toxic Vapor Detectors for N_2H_4, MMH, and for HCI:
  1. Personal dosimeters capable of measuring TLVs with total accuracy of +25% on 5-minute exposure.
  2. Portable survey meters with range of 0 to 10 times TLV with total accuracy of +25% and response time of 30 seconds for 90% of change to new value.
  3. Length of stain tubes capable of measuring TLVs with total accuracy of +25% of reading in 30-120 seconds.
  4. Continuous area monitors capable of operating 30-60 days without maintenance or adjustment, measuring over range of 0-10 times TLV with total accuracy of +25% of reading, and a response time of 30-60 seconds for 90% of change.
- Temperature Sensors
  —Innovations leading to the development of a high speed gas thermometer. Pneumatic impact initiated ignitions have been the cause of some serious fires in high pressure oxygen systems. Adiabatic compression of the system gas is one possible cause of the high temperatures leading to ignition. A high speed (approximately 1 millisecond) non-contact means of measuring the gas temperature is needed that is capable of making measurements through small (0.25 cm) windows or through fiber optics.
- Pressure Sensors
  —Dynamic pressure sensor to measure the near-field dynamic pressure in a free field blast environment. Blast intensity will be in the range of 10 kg TNT equivalent. Response time should be in the order of a fraction of a microsecond.
- Other Instrumentation
  —A miniature physiological telemetry system capable of transmitting 6 channels of temperature, an ECG, voice and pressure a distance of 1 km.

13.02 Subtopic: GROUND CHECKOUT COMMUNICATIONS

Center: KSC

Innovations are solicited for improvements in ground checkout communications systems used in the processing and checkout of space systems hardware.

Specific areas of interest include, but are not limited to, the following:

- Microwave remoting via fiber optics: This development would be useful in microwave antenna remoting applications, such as for large area phased arrays, or for point-to-point links where there are obstacles in the line-of-sight radio path, or where it is desired to put the signal processing circuitry at some distance from the antenna location.
  —A practical, inexpensive means of transmitting a block of microwave signals over a single optical fiber without significant degradation of signal quality;
  —Design goals are: (1) Ku band operation, or nominally 12 gigahertz, and (2) a block bandwidth of 5% or more;
- Wireless, digitally encoded headset for communications: Process or system which will allow communication headset interfaces without a wire connection while maintaining a unique voice path to each headset. This would provide unencumbered headset usage.
  —The required innovation would allow multiple headsets to operate simultaneously and independently without interference or crosstalk;
  —The innovation should allow a range of greater than fifty feet from headset to base unit and provide omni-directional field pattern.

13.03 Subtopic: Launch Processing Quality Assurance Technology

Center: KSC

QA activities during launch site processing consist of inspection, surveillance, and implementation of control systems to ensure quality. Much of this effort is manual and requires significant resources and maintenance of considerable paperwork. Technological innovations are desired to improve efficiency and QA techniques in areas including the following:

- Video/audio/micro-image technology to provide high-quality records of close-out inspections, shipping inspections, troubleshooting, test monitoring, etc., in lieu of today's manually kept paperwork and still photos.
- Methods to automatically read part numbers during modification installations such that configuration controls are continuously maintained, incorrect parts are immediately identified, so that QA does not have to keep manual records.
- Integrity control technology that would positively and in a timely fashion identify any violations of closed systems/areas and eliminate the need for the undesirable paper and lead seals.
- Methods/systems to provide timely identification of recurring hardware problems, to analyze problems for trends and positively flag candidates for recurrence control.
- Methods/systems to automatically and positively track the life and use of consumables, such as adhesives or lubricants, on flight hardware and provide a means to identify and prevent/correct applications of consumables found to be nonconforming.

13.04 Subtopic: Robotic Ground Processing of Space Systems and Components

Center: KSC

Innovative end-effectors/grippers are desired to support the automation of Space Shuttle/Space Station ground operations. Examples of devices desired include:

- Robotic grippers to mate/demate hazardous fluid couplings. A robotic end-effector using a gripper to handle the coupling and attached line while preventing the backshell from rotating could be combined with a rotary driver/gear assembly, to effect mate or demate rotation. Sensors on the gripper or embedded into the coupling would provide information to enable proper seating and prevent unmate operations during the presence of toxic vapors.
- A dexterous end-effector with one or more arm-like hands mounted to a box containing "intelligence." The smart end-effector could be attached to a heavy-lift industrial robot and be used for various applications requiring simultaneous use of end-effectors. The arms mounted on the "box" could simulate the arm movements and reach envelope of a human for accessibility to working area and tool compartments. The robot arm would position the box in front of different panels/hardware and it could autonomously perform pre-taught operations. The intelligence of the end-effector would be a programmable microcomputer allowing the "box" to be universally used for many servicing operations requiring more than one robot or requiring more dexterity than conventional gripper mechanisms presently allow.

13.05 Subtopic: Production and Handling of Aerospace Fuels and Propellants

Center: KSC

Innovations are sought in support of aerospace fuel/propellant logistics. Specific areas of interest include:

A. Enhancements to Self-Contained Atmospheric Protective Ensemble (SCAPE)

- During cold weather operations, the temperature inside the SCAPE suits (propellant handler's protective suit) is lower than desired. A lightweight, noncontaminating, portable heat source which can be worn inside the suit without affecting mobility is desired.

- An improved glove which provides increased resistance to puncture and abrasion and provides increased flexibility is desired. Material must be compatible with hydrazine, monomethylhydrazine and nitrogen tetroxide.

B. Measurement of Hydrogen Ignition Pressure

- The pressure generated by hydrogen igniting in air is a function of the quantity of hydrogen, hydrogen-to-air mixture ratio, the availability of an ignition source, the distance between the ignition and the point of measurement which may absorb energy. It is desirable to obtain more data concerning hydrogen ignition in air to better define its effect on space launch vehicle equipment and facilities. In order to conveniently run tests to obtain such data, innovation leading to the the development of equipment which can readily mix known quantities of hydrogen with known quantities of air and mix and ignite them without the contaminant affecting the pressure generated is desired.
- Another device that would be beneficial is a pressure measuring device that would absorb the pressure wave over a large surface area. This would enable a more accurate reading because the pressure wave would be amplified and averaged by the large area. This would enable tests to be run using smaller expositions and/or greater distances.

C. Hydrazine Purification

- A simple method to remove hydrocarbons (particularly aniline) from hydrazine (N_2H_4) is desired. The process is to be easy to start up, shut down, and operate since volumes required are generally small (100 gallons) and requirements are intermittent. The present purification method requires shipment across country and is a high cost, low yield (60%) process. An on-site process, simple to operate with a high yield, is desired.

D. Spent Hypergolic Fuel Scrubber Solution Treatment

- The spent hypergolic fuel scrubber solution consisting of citric acid, water, and monomethylhydrazine citrate is presently incinerated. An alternate method of treatment which would produce environmentally innocuous compounds at reduced cost is sought.

E. Explosion and Fragment Data Collection

- A need exists for empirical data on the distribution and characteristics of primary and secondary fragments resulting from explosions. An innovative system for reporting significant explosions and recording fragment data as well as an innovative method for data collection and interpretation is sought. For the system to produce the desired results, response must be fast and data collection thorough and fast enough not to interfere with desired cleanup activities.

13.06 Subtopic: Flow Measurement Device for Ground Test and Checkout

Center: MSFC

The checkout of thermal control fluid systems often requires that flow measurements be taken in order to proportion flowrates in multiple loop systems. In a low differential pressure system the installation of a flow meter for ground testing can alter the system flow characteristics sufficiently to render data collected inaccurate. An innovative method is needed for accurately measuring flowrates in closed loop systems without altering the characteristics of the system itself. Typical systems would include high purity de-ionized water and freon coolant loops used for thermal control in materials processing experiments and payloads.

13.07 Subtopic: Nondestructive Evaluation

Centers: KSC
LaRC

Reliable performance and durability of advanced materials for application in critical aerospace components depend on the assurance that each part placed in service satisfies the conditions assumed by design analyses and predictions of service life. The need includes all aspects of materials including materials/structures for electronics. This requires advanced non-destructive evaluation methods from fundamental materials characterization to verifying components/systems in a real-time environment. These methods should be sensitive to variations in the microstructure of materials, morphologies, properties, and flaw populations which can affect behavior, reliability, and durability. Achieving the required advancements requires the identification of novel concepts in non-destructive methods of evaluation supported by a firm basis of fundamental information from material science measurement science.

Innovations are desired in non-destructive evaluation techniques to characterize the microstructural, mechanical, physical, and electronic properties of materials with approaches that go beyond defect detection and characterization. The objectives, therefore, are to provide methods for quantitatively assessing material properties, along with the population of flaws that govern or influence mechanical, physical, and electronic behavior, reliability and residual life.

13.08 Subtopic: Launch and Landing Site Weather
Center: KSC

A. Specialized weather forecasting: Innovative forecasting methods applying newly developed atmospheric science in the mesoscale are required to predict the development of interfering weather such as thunderstorms and other severe conditions. Precise forecasts are required at 30 minutes, 2 hours, and 72 hours prior to operations to adjust schedules and/or implement alternate plans in processing, launch, and landing of aerospace vehicles. The goal is to reduce weather interference on operations by 65%.

B. Clear air wind velocity sensing using doppler radar: Clear wind velocity sensing using a doppler radar has been determined to be an important sensor for developing highly reliable thunderstorm forecasts. KSC is developing and implementing a prototype Clear Air Doppler Radar (CADR) for research and development. This prototype will be available for testing and technique development. KSC also has extensive ground-based meteorological instrumentation. Innovative techniques for CADR design, Doppler velocity unfolding, multiple-Doppler techniques, data transformation, display, analysis and forecasting are required to support the development of an operational STS support CADR.

TOPIC 14.00 SATELLITE AND SPACE SYSTEMS COMMUNICATIONS

14.01 Subtopic: Advanced Communications Satellite Systems
Center: LeRC

Innovative advanced concepts are required for devices, components, subsystems, and operating techniques that support the emergence of new and improved satellite communication services for commercial and government applications including inter-satellite. Applications at all allocated frequencies are of interest but with particular emphasis at Ka band and above, including optical, although many concepts may be frequency independent. General areas of interest include RF/optical devices, components, and subsystems; processing and switching components, subsystems and systems employing digital and analog/digital hybrid concepts; and antenna systems using active arrays in feed and direct radiating configurations. Performance improvements in RF components are sought in bandwidth, power, and efficiency. New technologies for processing and switching should be targeted toward data, packet or message switching/routing, onboard message processing, onboard network control and associated low-cost ground terminals. Onboard factors to be considered are implementation complexity, reliability, size, weight, and power. Ground terminal factors to be considered are cost reducing implementations, complexity, ISDN compatibility, and reliability. Implementations using electronic technologies are being sought for near-term applications (present to 1997). Research in photonic technologies is desired for applications in the longer term (1997 and beyond). Of particular interest with respect to commercial applications are concepts which, if developed, will put the U.S. developer in a strong position with respect to foreign competition. Innovative approaches are desired in the following specific areas:

- Research on existing and new RF devices and components (solid state or free electron) to improve performance, i.e., higher frequency, bandwidth, power, and efficiency.
- New concepts to make use of improved RF devices in advanced satellite communications circuits.
- Novel concepts for components and subsystems (frequency sources, receivers, amplifiers, mixers, combiners, power dividers, transmitters, etc.) which should stress improvements in bandwidth, power, efficiency, noise figure, gain, reliability, or cost, as well as higher frequency performance, miniaturization, and improved circuit and packaging techniques.
- Research into applications combining electronic and photonic technologies where incoming RF signals are converted to photonic information and photonic information is converted to outgoing RF power.
- Flexible, reliable, high speed, onboard data, packet or message switching/routing systems at baseband, IF or optical frequencies to meet the throughput and interconnectivity needs of efficient high and low-data-rate FDM and TDMA communications among a large network of low-data-rate users are technology issues. Such onboard systems required the development of modulation/demodulation, coding/decoding, data, packet or message switching and digital processing technologies.
- Advanced coding and modulation schemes to provide efficient use of the frequency spectrum and adequate bit-error-rate for reliable communications.
- Supporting demodulator implementations that respond to objectives of cost-reducing implementations or adaptations for multiple modulation schemes/rates.

- Flexible high-speed coder and decoder implementations for applications at data rates above 100 MBPS.
- Digital processing concepts and components that support signal acquisition and synchronization in TDMA demodulation, simultaneous multiple FDMA channel demodulation, switching/routing, and onboard network control.
- Advanced concepts for on-board TDMA communications network control.
- Cost-reducing concepts and technology components for high and low-data-rate TDMA ground terminal digital systems providing initial acquisition, transmit and receive burst data control, timing and synchronization, or terrestrial interface.
- Large reflector antenna distortion compensation techniques: The thermal environment of large reflector antennas in geosynchronous or low Earth orbit can result in periodic distortion in the reflector and/or antenna support structure and thereby degrade RF performance. As frequencies of operation and the size of antennas increase, the distortions become more of a problem. Many efforts involving the development of special materials or structural techniques are being made to reduce these distortions. An alternate (or complementary) approach to the problem would be to compensate for distortion using the large number of degrees of freedom available in phased array feeds with large numbers of radiating elements.
- Novel approaches or concepts for active feed array compensation for thermal distortion effects. A related problem of interest is the measurement or detection of reflector/antenna structure distortion on a continual or intermittent basis. Proposed approaches or techniques must be sufficiently accurate, be compatible with reflector antenna deployment schemes, and be efficient in terms of spacecraft power, weight, size and reliability requirements.
- Advanced applications of MMIC technology for wide angle scan antennas: Monolithic Microwave Integrated Circuit (MMIC) devices are becoming available at Ka band frequencies. Novel approaches are required for wide angle (up to hemispherical) scanning at Ka band using the large number of degrees of freedom inherent in arrays/array feeds with MMIC devices. Concepts for entire systems or for critical elements of complete systems are desired. Applications include systems for linking LEO satellites/stations to ground terminals, GEO satellites, or maneuvering space vehicles.
- Large phased array antennas using large numbers of MMIC elements in beam forming/control networks pose some unique problems in assembly and integration. Of particular interest at this time are techniques for electrical control and thermal dissipation. Research is desired in optical and photonic technologies for transmitting signal and/or control information to the MMIC devices. Research into packaging and assembly techniques is desired for adequate thermal dissipation and control.

14.02 Subtopic: Satellite-Based Mobile Voice and Data Communication Services

Center: JPL

Innovations in network protocols, spread spectrum modulation approaches and network simulation hardware and software are desired to develop new and better mobile communication services for voice and data communications using satellites. The goals are to maximize the number of users (more than 1600 simultaneous channels), to have less than 40 milliseconds delay (excluding propagation delay), and to have quick recovery after deep fades that are typical of mobile services.

New techniques of hardware and software for equipment and network simulation of large population, geographically dispersed and mobile terminals in a variable channel request and channel assignment strategy, fading propagation environment are desired. The following factors should be considered in the design of such equipment and systems:

- Operation at L-Band (1.5 GHz).
- RF channel bandwidth is 9 MHz.
- Digital voice/data bit rate to be 4.8-9.6 kbps.
- System should perform well over a Rician Fading channel with Rician parameters of 10 dB. Speeds up to 100 miles/hour to be considered.
- Mobile antenna is omnidirectional with low gain (4 dBic at 20 degrees elevation).
- Bit error rate requirement is 10^{-3} at average received Eb/No = 10 dB or better at 4.8 kbps.
- Transmitter and receiver should be low cost-small size with low power requirement.
- The network testbed must include the multipath fading and shadowing effects of the mobile-to-satellite L band link which uses single 5KHz channel per carrier, tunable within a total channel bandwidth of 9MHz at 4800 bps data rate.

14.03 Subtopic: Monolithic Distress Beacon

Center: LeRC

Satellite-aided search and rescue distress beacons have saved hundreds of lives through the joint USA/Canada/France/USSR COPAS-SARSAT program. Consisting of a network of polar-orbiting satellites, this system monitors specific frequencies to detect and locate the distress beacon transmitter. Currently available 406 MHz beacons provide greater position determination of the distress beacon than the 121.5 MHz beacon, however the cost is considerably higher. Innovations are needed to develop low cost monolithic circuitry to be used in COPAS-SARSAT 406.025/121.5 MHZ beacons. Innovations should address, but are not limited to the following:

- GaAs circuit applicability;
- Total monolithic construction of the entire beacon circuit;
- Highly stable 406 MHz oscillators with stability of better than 2 parts per billion;
- Operational temperature range −40C to +65C, minimum;
- Nominal operation should be reached within 15 minutes;
- Must sustain an initial temperature shock of 30C;
- Nominal power output of 5 Watts into 50 ohms;
- Data word is 144 bit, phase modulated at 400 bps rate;
- Duty cycle of 500 milliseconds every 50 seconds;
- Specific innovations are needed to minimize power, cost and weight.

14.04 Subtopic: Communications for Manned Space Systems

Centers: GSFC
JSC

Innovations are sought for both external and internal communications subsystems in manned space systems. These subsystems are complex from the standpoint of a great variety of services (voice, commands, telemetry, video, text, graphics etc.) and require a large number of interactive links. Multiple, simultaneous links will be required to communicate among the variety of elements within the STS and Space Station including satellites and extravehicular astronauts. Internal communications must accommodate increasing crew sizes, and overall management and control of the communications systems must be highly automated.

- Advanced multiple beam antenna systems with near-hemispherical coverage at 13-18 GHz for supporting simultaneous FDMA users are required for future NASA missions. User omni-directional antennas at these frequencies with low power, lightweight detection/switching schemes are needed.
- Personal communications systems for Space Station are needed. Multiple users, user access and remote controls, distributed antenna system, and portable data terminals are some key features for advanced systems implementations.
- Crew communications: Multiple-access wireless communications for up to 12 crewmen is required to allow simultaneous communication with no restriction on individual orientation within a single enclosure. Equipment worn by the crewmen must be small and lightweight to avoid interference with crew activities. Electronic noise cancellation is desired.
- Solid-state text and graphics: A solid-state graphics imaging device consisting of at least 4,000 individual light sources capable of illuminating corresponding points along a horizontal scan line is needed for initial application on the Space Station.
- Fiber optics for secure communications: Novel systems for secure communications utilizing fiber optics are needed. Specifically, electronic components powered by optical energy (transferred through a fiber optics path) for totally secure logic is one approach of interest. This scheme will eliminate the need for electrical conductors supplying power to the encrypting equipment.
- Communication system modeling and simulation: The need exists for development of generalized mathematical models and integrated software packages to allow simulation and evaluation of the performance of candidate one-way and two-way multi-access communications systems, such as those envisioned for the Space Station. These computer simulations allow trade-offs on the basis of key parameters which include bit error rates, jamming environments, power requirements, complexity, and cost. The models should also include expert system and artificial intelligence implementations.
- Video systems for robotics and automation: Innovative design approaches for small size and lightweight, digital, solid state imaging, display, and processing systems are needed for robotics and automation applications. Design features include high definition for large scenes, high grey-scale resolution, data compression og higher order with quality imagery, and scene recognition and attitude determination capabilities.
- A laser or photo-electric short range (<60 feet) telemetry system for standard services in the payload cargo bay with a transmitter hardwired to the standard switch panel which would have a swivel mount to communicate via a "line of sight" signal beam, to a receiver mounted on the payload or experiment. Such a system would eliminate many changes to the ship's wiring harness and would also permit mounting of cargo in locations inaccessible to Orbiter standard service instrumentation patch panels.

These systems must be developed for space environments.

14.05 Subtopic: Multiple Function Antenna Feed
Center: JPL

A need exists for a circularly polarized, multiple function focal point feed for MMII deep space probe high gain antennas. The feed is required to properly illuminate a 1.47 meter diameter reflector for generating a high gain beam and also to serve as a low gain antenna. The low gain beam is directed along the axis of the high gain beam and has a wide spread pattern. The feed shall be capable of being switched to simultaneous transmit and receive in either high gain or low gain mode of operation, or transmit in high gain while receive in low gain.

Innovative techniques for this feed are required. The feed shall be compact and highly efficient such that the following performance criteria of the antenna system are met:

- High gain antenna efficiency requirements (measured at the input to the feed):
  65% minimum at 8.4 GHz (downlink);
  50% minimum at 7.1 GHz (uplink);
- Low gain antenna gain requirements:
  7 dBic minimum at 0-degrees (beam axis);
  −13 dBic minimum at ± 120-degrees from beam axis;
  <2 dB ripples on gain pattern from 0-degrees to ± 120-degrees from beam axis.

14.06 Subtopic: Optical Communications for Deep Space
Center: JPL

Deep space exploration spacecraft of the future will use optical frequencies to communicate back to near-Earth orbit or possibly directly to the ground. Innovations for such systems are needed in several areas:

- Due to the long propagation distances and stringent spacecraft power limitations, the signal intensities will be very small at the Earth. Innovative concepts are needed for developing lasers which have high power conversion efficiency (approximately 10%), produce single and stable far field beam profiles, and which can be easily modulated using a pulse position modulation format with high peak pulse energies (0.1mJ). CW laser sources are also needed for heterodyne systems which produce very stable output frequencies, as are design approaches and concept verifications for coherent optical transponder functions.
- The narrow beamwidths require accurate pointing and focal plane detector arrays which have the ability to provide pointing information electronically, but the readout rates of the arrays may limit the overall spatial tracking bandwidth. Therefore, innovations leading to a high gain, focal plane detector array with electronically controlled cursor readout would be very beneficial. Desires are for a KHz readout rate (with single or multiple pixel readout), a gain of one million, and a responsiveness better than an S-20 photocathode.
- For detection of such optical signals, large-aperture (greater than 5 meters in diameter), inexpensive, non-diffraction limited optical reception telescopes for use on the ground or in space will be required. Reception wavelengths for these "photon buckets" are in the 0.5 to 1.2 micron region. Concepts and design verifications are also sought for using such telescopes at small angles off the solar limb (i.e., at small Sun-Earth-spacecraft angles).

TOPIC 15.00 MATERIALS PROCESSING, MICRO-GRAVITY, AND COMMERCIAL APPLICATIONS IN SPACE

15.01 Subtopic: Materials Processing in Space
Center: LeRC
MSFC

Opportunities for commercial processing of materials exist in the low gravity of space. Some of the areas in which such opportunities exist, and in which research innovations are sought, are listed below:

- Materials:
  —Electronic Materials—Improved materials for semiconductors and solid-state detectors of high purity, volume or high intrinsic value for use in electronics, computers, communications and medical instrumentation.
  —Metallic Alloys—New alloys made from immiscible components, improved grain structures for alloys of miscible components, directional solidification, and process involving supercooling and rapid solidification from an undercooled state.
  —Glasses and Ceramics—Containerless processing of glasses should eliminate crucible-derived impurities, give better control of nucleation sites, and provide the possibility for dealing with highly reactive melts. Improved optical fibers may result from surface tension forming from melts in a containerless process.
  —Biological Materials—Processes for obtaining specific cell types, cell components, hormones, antigens, proteins and other organic and crystalline substances with greater purity and throughput.

Continuous electrophoresis and isoelectric focusing are two separation methods that benefit from the micro-g environment. In addition, the crystallization of proteins in order to determine structure and other properties is a topic of considerable interest.

—Electro-optical Materials—Processes for obtaining materials for electro-optical applications, particularly in the emerging new field of photonics, are new R&D topics for space processing. Both organic and inorganic materials are of interest.

- Technological Phenomena and Techniques:

  —Fluid dynamic phenomena are involved in a wide range of technologically important processes that are affected by weightlessness. Multi-phase flows in a complex regime of thermal and solute gradients are altered by the weightlessness conditions of space. These alterations are applicable to a range of R&D such as crystallization processes, separation processes, phase change phenomena, solidification mechanics, solute-solvent processes, glass processes, etc. Innovation leading to improved understanding for thermodynamic and fluid processes in weightlessness will lead to greater exploitation of materials processing in space.

  —Processing Techniques necessary in the technology and scale-up of specific devices and processes include, for example, acoustic, electromagnetic and electrostatic levitation devices; continuous-flow electrophoresis; isoelectric focusing; cell culture and deposition; furnaces of all types; combustion processes; isotachophoresis; and surface tension manipulation. Approaches to developing new processes, instrumentation and control procedures, and characterization of materials are essential enabling activities.
- Apparatus and equipment, including containerless melting, solidification and fiber-pulling devices, heat-pipe furnaces for directional solidification, efficient furnaces for float zone growth and high temperature containers that can withstand large temperatures differentials (greater than 500C).

15.02 Subtopic: Solidification Processing Concepts

Center: LeRC

Innovations are sought in the following areas:

- Solidification processing concepts, such as rheocasting, drip casting and rapid solidification. Rapid solidification via chill block melt spinning has the potential for quenching at approximately 1,000,000 degrees per second and producing ultrafine grain sizes and precipitate distributions for new strengthening concepts in metals, alloys, and intermetallics.
- Intermetallic compounds of the near equiatomic (B2 structure) nickel and iron aluminides have the advantages of light weight, oxidation resistance, and high melting points. High temperature strength and room temperature ductility are goals for innovations in:

  —Processing, e.g., melting, powder metallurgy, and rapid solidification techniques to assure high-purity starting materials.

  —Alloying concepts to improve ductility and strength.
- Metal matrix composite materials:

  —Fibers having high strength and with thermal expansion coefficients matching those of metallic matrices.

  —Matrices which are lightweight and capable of high temperature (1800-2100F) applications in aerospace structures.

15.03 Subtopic: Microgravity Science, Technology and Engineering Experiments

Center: LeRC

- Definition and Development of In-Space Experiments.

Innovations leading to the definition and development of in-space experiments and the development of basic, core equipment and facilities required for quality space laboratory experimentation are solicited, using unique government research facilities in the study of microgravity processes/phenomena and the definition of space flight experiments which are available at the Lewis Research Center, Cleveland, Ohio. These facilities include several which provide varying degrees and times of simulated microgravity microgravity conditions and the Microgravity Materials Science Laboratory (MMSL). MMSL provides easy access and assistance to scientists and engineers from industry and universities wishing to conduct materials research using Shuttle flight-type experimental equipment.

Of particular interest are proposals emphasizing innovative commercial applications. Areas of interest in microgravity science and applications are fluid and transport phenomena, combustion, metals and alloys, glasses and ceramics, polymers, and electronic materials. Research, technology, and engineering areas include energy conversion and space power systems, fluid and thermal management systems, space environmental effects, and spacecraft fire safety. New concepts in basic laboratory equipment and practices range from fundamental diagnostic and property measurement techniques and data recording and storage to sample preparation and waste product disposal systems.

- Space Station United States Laboratory Module Experiments.

During the definition and preliminary design phase of the Space Station, NASA has defined the functional characteristics of a range of microgravity experiment facilities to be accommodated by the pressurized United States Laboratory (USL) module. The requirements for these user-provided facilities are based on extensive discussions with current and potential users of microgravity facilities. Some of these facilities are in the concept design phase. Many will require advancements in technology to enable or enhance their development and provide the capabilities to satisfy users' requirements.

The microgravity experiment facilities of interest to LeRC are those needed to perform experiments in the Space Station USL module in the microgravity science and applications disciplines of metals and alloys, electronic materials, glasses and ceramics, combustion science, polymers and fluid and transport phenomena. General technology areas where innovative advancements are needed to enable or enhance development of these facilities include instrumentation and sensors, unique mechanical devices, high-temperature materials, automation/process control, non-intrusive diagnostics and acceleration/vibration environment control.

15.04 Subtopic: Chemical Vapor Deposition Analysis and Modeling Tools

Center: LaRC

Chemical vapor deposition is one of the key technologies of the electronics industry. To foster this development it is essential that predictive models be developed to compare the results of early microgravity testing with scientific theory and ground-based empiricism. The prediction of the fundamental fluid flow and reaction phenomena taking place under varying gravity fields requires innovations in computational methodology. This subtopic seeks innovative development of a general purpose fluid flow simulation program that predicts in three spatial dimensions the mass, temperature, momentum, energy, and chemical species distributions during the chemical vapor deposition of electronic materials and presents the results in both tabular and graphical formats.

15.05 Subtopic: Reduced Gravity Process Chemistry

Center: JSC

Potential commercial processes (such as separation of biologicals and crystal growth) are known to benefit from reduced gravity. Several areas in which the removal of the gravitation energy might affect chemical processes remain unexplored and offer the opportunity for innovation, including at least the following:

- Catalytic, biochemical or organic processes in which very small energy differences separate alternative products.
- Processes in which gravitationally unstable arrangements of reactants are necessary for production or isolation of products.
- Processes in which electrical, magnetic, or other forces may enhance or modify process chemistries under reduced gravity.
- Techniques for handling, mixing, separation, and manipulation of reactants, intermediates, and products at low gravities.
- Techniques for process control and/or monitoring in reduced gravity.

15.06 Subtopic: Life Science Commercial Research and Applications in Space

Center: ARC

NASA has made a commitment to support extensive life science research activities in orbiting spacecraft, including a life science research laboratory on the Space Station. Innovative research and new advanced technologies are required to exploit these opportunities; proposals emphasizing commercial applications of innovative research will receive special attention. Areas of interest in life science and applications include the following:

- Bioprocessing
  - bioreactor technology
  - protein crystal growth
  - protein separation/identification
- Space Medicine Research
  - advanced biomedical instrumentation
  - countermeasures to effects of space flight
  - rehabilitative and geriatric medicine
- Animal/Plant Specimen Testbeds for Long Duration Space Biology
- Global Habitability

New concepts in basic systems and subsystems include gas, fluids, temperature/relative humidity control, illumination, waste collection, food/water/nutrients, dispensers, robotic manipulators, and video and biotelemetry monitoring systems. Also, specimen-unique habitats for various specimen types including rodents, primates, plants, amphibians, and fish should be considered as critical subsystem elements.

APPENDIX E

NASA SBIR 87-1

PROPOSAL CHECK LIST

(Attach Proposal Check List to Original Cover Sheet and Project Summary)

Company: ______________________

____

____

Proposal Number: ____.____-________

Proposal Title: ______________________

____

ITEM	CHECK	NASA USE
1. Proposal package includes		
a. Five (5) copies of Proposal per Section 3.3	____	____
b. Separate original (red) Cover Sheet and Proposal Summary (Appendices A and B)	____	____
2. Proposal addresses one and only one Topic and Subtopic	____	____
3. Proposal is no more than 25 pages, 8½″ x 11″	____	____
4. Appendices A, B, and C completed according to instructions, and		
a. All certifications are made	____	____
b. All signatures are provided	____	____
5. Proposal includes all information required in Section 3.3, and arranged in requested order	____	____
6. No proprietary information included in Project Summary, Technical Objectives or Work Plan	____	____
7. Any proprietary information submitted is contained in Proprietary Addendum, and the Proprietary Notice included on Cover Sheet	____	____
8. Funding request does not exceed $50,000. If cost proposal exceeds $50,000, cost information explains who will provide the difference	____	____
9. Period of performance does not exceed 6 months	____	____
10. Offeror is aware that proposals must be received in NASA Headquarters by 4 p.m. EDT June 19, 1987	____	____